

14. *The Girdles and Limbs of the South African Deinocephalia.* By LIEUWE DIRK BOONSTRA, D.Sc.

(With 6 diagrams, 108 text-figures and Plate XXV.)

I. INTRODUCTION

In this communication I intend describing the pectoral and pelvic girdles and the fore- and hind-limbs of the large number of Deinocephalian specimens housed in the South African Museum in Cape Town. The nature of the material determines the method of treatment, which will in this case have to assume, in the taxonomic part, the form of an illustrated catalogue.

In all, the Museum Register contains 106 separate specimens in which some part or other of the girdles or limb-bones is preserved. In a very large number of cases these postcranial elements are not associated with any cranial material and identification is thus rendered difficult in view of the fact that authors in the past have usually made skulls and jaws "types". Moreover, in many cases the specimens consist of isolated individual bones which, being unassociated with other elements of the postcranial skeleton, makes the task of identification no easier.

All the specimens were collected in the *Tapinocephalus* zone of the Lower Beaufort; nearly all in the area known as the Koup, which includes parts of the districts Beaufort West, Prince Albert and Laingsburg, with only a couple from the area north of the Nieuvelveld Escarpment in the districts of Sutherland and Fraserburg.

Rossouw (26) has recently subdivided the *Tapinocephalus* zone into three subdivisions, and it is of interest to record that the specimens to be described here come mostly from the lower subdivision.

Since the Museum's first acquisition in 1904 the following collectors have contributed to the collection of Deinocephalian girdle- and limb-bones: Cloete, Oakley, le Roux, du Plessis, Cairncross, Maddison, Whaits, Haughton, van der Byl, Boonstra, Avenant and Marais. Of these, Haughton with 18 and Boonstra with 65 specimens are the more important collectors.

2. HISTORICAL AND MORPHOLOGICAL

A. *The Pectoral Girdle* (Diagram 1)

In 1889 Seeley (28) figured a coracoid and incorrectly interpreted it as the pubis of *Titanosuchus*. Broom (8) in 1905 mentioned parts of the shoulder

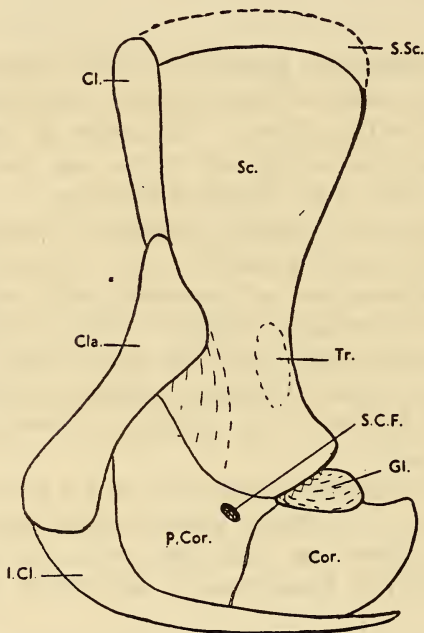
girdle of *Pelosuchus*. In 1914 Watson (29) figured the scapulocoracoid of *Phocosaurus* and described the scapula, coracoid and cleithrum of *Titano-suchus*. In the same year Broom (11) figured and described the shoulder girdle of *Moschops*, and on the same material Gregory and Camp (17), Romer (25) and Gregory (18) based their figures and descriptions. In 1914 Broom (10) also published a photograph of a Titanosuchian pectoral girdle (A.M.N.H. 5611) under the name *Tapinocephalus atherstonei* in error, and this scapulo-

coracoid was later figured by Gregory (18) under the name "*Tapinocephalus*" to indicate his lack of confidence in Broom's identification. In 1915 the pectoral girdle of *Struthiocephalus* was shown in Haughton's (20) photograph of the mounted specimen in the South African Museum. Broom (14) in 1929 figured and described the pectoral girdle of *Jonkeria truculenta*. In 1931 von Huene (21) figured an interclavicle, which he thought was that of a Titanosuchid. In 1940 Byrne (16) described and figured parts of the girdle of *Moschoides*. Although pectoral elements are mentioned in connection with some of the other described Deinocephalians, they were neither figured nor described.

In the South African Museum collection the pectoral girdle is well represented. The scapula is preserved wholly or in part in 36 specimens, the coracoid in 16, the precoracoid in 12, the interclavicle in 15, the clavicle in 5, whereas the cleithrum is only preserved incompletely in 1 specimen.

The Deinocephalian pectoral girdle is composed of 11 bones — one unpaired bone and five pairs — as is the case in all primitive reptiles. These are the interclavicular, a pair of scapulae, coracoids, precoracoids, cleithra and clavicular. With which in life a cartilaginous sternum was probably associated. These eleven bones together form a U-shaped framework encasing the thorax and is supported semi-slung by the paired fore-limbs.

Diag. 1.



Semi-diagrammatic sketch of a Titanosuchian pectoral girdle in lateral view. Cl.—cleithrum; Cla.—clavicle; Cor.—coracoid; Gl.—glenoid; I.Cl.—interclavicle; P.Cor.—precacoid; Sc.—scapula; S.C.F.—foramen supracoracoideus; S.Sc.—suprascapula; Tr.—mound, ridge or tubercle from which the scapular head of the m. triceps originates.

Ventrally the interclavicle, bisected by the median line, forms the connecting link between the two limbs of the U. Each limb is formed by the more or less vertically disposed scapulo-coracoid, which consists of a dorsal bladelike scapula and a ventral, antero-posteriorly elongated, coracoidal plate formed by the large precoracoid and a smaller coracoid. The lower edge of the coracoidal plate rests on the stem of the interclavicle, which sometimes carries a strong median ridge against which the coracoids abut.

On the posterior surface of the scapulo-coracoid, at the junction of the scapula and the coracoid, lies the simple, antero-posteriorly shortened, glenoid cavity, which receives the shortened oval head of the humerus. The glenoid has a dorsal facet lying in the scapula and this faces ventro-posteriorly but sometimes also slightly externally, and a ventral facet on the coracoid facing dorso-posteriorly and also much externally. The nature of the glenoid cavity makes the humerus lie with its distal end somewhat or fairly much lower than its proximal end. Moreover, it limits the anterior disposition of the humerus.

On the posterior border of the scapula, some distance above the glenoid, lies a mound, or ridge or a prominent tubercle, from which the scapular head of the triceps originates. Along its anterior border the scapula is flanked by the elongated cleithrum, which in the Tapinocephalia is, where known, a rudimentary splintlike bone, but in the Titanosuchia is still functional as a fairly strong elongated element with a spatulate dorsal end projecting above the upper edge of the scapula, to which a cartilaginous suprascapula was attached in life. Below the cleithrum and lying along the anterior edge of the scapula and precoracoid is the long platelike clavicle, which in the Titanosuchia, and to a lesser extent in the other forms, dorsally overlaps the lower end of the stem of the cleithrum, fitting into a groove in this bone. In all the Deinocephalia the clavicle, where known, has its widely spatulate ventral end clasping the upturned antero-lateral external surface of the interclavicle, which develops a more or less deep groove for the reception of the clavicle.

In the pectoral girdle the two coracoids and the scapula are more or less firmly joined by sutures to each other, with the other elements, the dermal bones, more loosely applied to them. Ridges and grooves limit the movements of the elements *inter se* and strong ligaments holding them together allow a fair amount of movement. There is considerable freedom of movement between the two halves allowing for difference of disposition when one fore-limb is disposed anteriorly and the other posteriorly.

As a whole the pectoral girdle is thus a massive structure of overlapping and supporting bones, united by suture or ligament, forming a strong but

The girdle is strongest in the Titanosuchia, where quick forceful movements are requisite for their carnivorous habits, weaker in the Tapinocephalia, whose habits were more leisurely and more aquatic, and in the Anteosauria it is weak, with the distinctive tricentral tubercle on the scapula, and a more crawling habit.

The Deinocephalian pectoral girdle shows definite advances beyond the morphological stage achieved by the Pelycosaurs. The more important advances are: the loss of the supraglenoid buttress and the supraglenoid foramen and the development in its stead of a mound, or ridge, or tubercle for the insertion of the scapular head of the triceps muscle; the antero-posterior shortening of the glenoid cavity, entailing the loss of the intricate "screw-shape" and the formation of a simple glenoid with a dorsal facet on the scapula and a ventral facet on the coracoid, and the glenoid, as a whole, facing ventro-postero-externally; the total exclusion of the precoracoid from the articulation in most forms, whereas in the others it forms no more than a small part of the anterior rim of the glenoid; the reduction in size and functional importance of the cleithrum (greatest in the Tapinocephalia, least in the Titanosuchia and probably also in the Anteosauria); the increase in size of the precoracoid, particularly antero-dorsally for the m. supracoracoideus, and concomitantly an extension of the area for the origin of the m. scapulo-humeralis; the loss of the dorsal process of the coracoid from which the coracoidal head of the triceps originated primitively; the development of a very strong interclavicle with a strong spatulate anterior end bent sharply upwards; the clavicle is a flat bone of considerable size.

The Deinocephalian pectoral girdle is less advanced than that of some of the higher Therapsids in that: no acromion is developed and there is no indication of the development of an incipient spina scapularis.

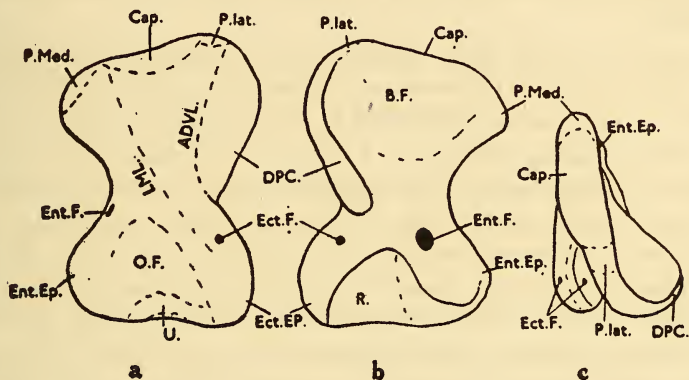
B. *The Fore-limb* (Diagrams 2 and 3)

HUMERUS

The first Deinocephalian humerus to be figured was one from Varsfontein, which Owen (23) in error referred to *Pareiasaurus*, and Lydekker (22) provisionally included in *Tapinocephalus*. In 1889 Seeley (28) figured a specimen from Koedoeskop as that of *Titanosuchus*, since it was said to be associated with the type skull fragments. Broom (7) in his description of *Scapanodon* mentions three humeri as possibly associated with the jaw fragments, but does not figure them. Then in 1909 Broom (9) made a humerus the type of *Eccasaurus priscus* and erroneously stated that it was from the Eccas Beds, whereas in fact, the farm Sandvlakte has outcrops of the *Tapinocephalus* zone of the Lower Beaufort Beds. *Eccasaurus* was

finally by Broom (15) considered to be one of the herbivorous *Tapinocephalia*, whereas, as will appear later, it is one of the carnivorous *Anteosauria*. In 1914 Broom (11) figured the humerus of *Moschops* and published (10) a

Diag. 2.



Semi-diagrammatic sketch of a Jonkerid humerus. a. Dorsal view. b. Ventral view. c. Proximal view. A.D.V.L.—anterior dorso-ventral line; B.F.—bicipital fossa; Cap.—caput humeralis; D.P.C.—delto-pectoral crest; Ect.Ep.—ectepicondyle (radial); Ect.F.—ectepicondylar foramen; Ent.Ep.—entepicondyle (ulnar); Ent.F.—entepicondylar foramen; L.M.L.—latero-medial line (separates the proximal and distal dorsal surfaces of the humerus); O.F.—fossa for the olecranon; P.Lat.—processus lateralis; P.Med.—processus medialis; R.—radial condyle or capitellum; U.—ulnar condyle.

photograph of the fore-limb of a *Titanosuchian*, which was erroneously referred to *Tapinocephalus atherstonei*. This humerus was subsequently figured by Gregory (18) without the ectepicondylar foramen being indicated. I located this foramen when at the American Museum in 1935 thus proving it to be *Titanosuchian* and not *Tapinocephalian*. In 1914 Watson (29), reviewing the *Deinocephalian* material in the British Museum (N.H.), figured an imperfect humerus of *Phigalion oweni*, and also located an ent- and ect-epicondylar foramen in Seeley's humerus of *Titanosuchus*. The humerus of *Struthiocephalus* is poorly shown in Haughton's (20) photograph and Broom's (15) reconstruction. In his comparative study Romer (25) figured the humerus of *Moschops*, as did Gregory (18). In 1928 Broom (13), discussing the confusion with regard to the British Museum material, figured a humerus, which he regarded as that of *Tapinocephalus atherstonei*, whereas, having two epicondylar foramina, it must be that of some *Titanosuchian*. The following year Broom (14) figured the humerus of *Jonkeria crassus* and briefly described, without a figure, a humerus identified as *Jonkeria* sp. and gave photographs of the humerus of *Dinosphageus* (= *Jonkeria*) *haughtoni*,

and stated that there is a humerus associated with the type skull of *Jonkeria pugnax*. Von Huene (21) figured a humerus identified simply as Deinocephalian, but clearly belonging to the genus *Jonkeria*. Finally Byrne (16) figured the humerus of *Moschooides*.

In the collection of the South African Museum 35 specimens have the humerus adequately preserved and a number where only unsatisfactory ends are preserved.

The humerus in the three divisions of the Deinocephalia, where it is known (Tapinocephalia, Titanosuchia, Anteosauria), shows certain distinctive characters but these are overshadowed by the features they have in common.

The Deinocephalian humerus is a fairly to very short bone, massive in the majority of forms, with greatly expanded ends and a short to very short, strong to very strong shaft. The proximal and distal expansions make an angle relative to each other because of a twisting on the shaft. The amount of this "twist" varies from about 10° to over 40° , but the usual twist is about $15-25^{\circ}$ and postmortem deformation usually accounts for the extremes.

The proximal surface of the humerus has in its median part the caput humeralis, which is oval in outline — sometimes narrowly and in other cases broadly oval. Its edges overhang the dorsal and ventral faces of the humerus to a varying degree. The face of the caput is only slightly convex, and, in life, it must have had a thick cartilaginous pad in order to fit the glenoid and make a relatively efficient shoulder joint. Postaxially the caput merges into the processus medialis, which in the Tapinocephalia and Anteosauria lies in about the same plane as the caput, but in the Titanosuchia the processus medialis lies in a plane slightly (Titanosuchidae) or much (Jonkeridea) distally of that in which the caput lies. Preaxially the caput flows into the processus lateralis, which in its turn is distally continued as the deltopectoral crest (D.P.C.). The processus lateralis usually forms the most proximal corner of the humerus and it limits the anterior disposition of the limb.

The distal end of the humerus differs considerably in the Tapinocephalia and Anteosauria on the one hand and the Titanosuchia on the other hand. In the former the capitellum or radial condyle is weak, not sharply modelled, transversely elongate and with little ventral swelling and its face does not extend in proximal direction along the ventral face of the bone; it is thus more distally situated and directed. Whereas in the Titanosuchia the capitellum is strongly bulbous, rounded and it extends moderately to very far proximally along the ventral face, in some cases right up to the plane in which the entepicondylar foramen has its ventral opening; its modelling is strong with sharp and prominent edges in some specimens; thus, although extending to the distal end of the bone, the capitellum is more ventrally situated and directed. The ulnar condyle is relatively weak and not

distinctly demarcated from the radial condyle and its mostly rounded but sometimes slightly trochlear surface lies distally and only just extends on to the dorsal surface; with, in some cases, a shallow trochlear fossa on the dorsal surface to receive the olecranon of the ulna when the epipodial is semi-extended.

Neither of the two epicondyles stretch distally of the articular surfaces. In distal view both epicondylar ends are very little thickened in the Tapinocephalia and Anteosauria, whereas in the Titanosuchia they are thick to very thick, indicating an important difference in the development of the flexors, extensors and supinators.

The proximo-dorsal surface is roughly triangular in outline, with the base situated proximally and the apex merging into the dorsal surface of the shaft. This surface is divided by the anterior dorso-ventral line (A.D.V.L.) into two parts. Anteriorly (preaxially) to this line lies the triangular upper face formed by the strong development of the delto-pectoral crest (D.P.C.). This large area (greatest in the Titanosuchia) is indicative of the presence of a very strong *m. deltoideus*. The ventro-distal corner of the delto-pectoral crest, to which was inserted the *m. pectoralis*, lies much further distally in the Jonkeridae than in the Tapinocephalia and, in particular, the Anteosauria. Both *m. deltoideus* and *m. pectoralis* were apparently much stronger in both groups of the Titanosuchia than in the Tapinocephalia and Anteosauria.

On the other part of the proximo-dorsal surface there lies the fairly weak oblique latero-medial line (L.M.L.), which is strongest in the Titanosuchia. The separate muscle-scars for the scapulo-humeralis, latissimus dorsi and the triceps on this surface are usually not clearly demarcated. But in the plane of the shaft a thickening on the L.M.L. is developed for the attachment of the lateral humeral head of the triceps and in some Titanosuchians a strong moundlike tubercle is developed here.

The dorso-distal surface is also roughly triangular with the apex directed proximally and dying out on the surface of the shaft. Distally this surface is moderately to very greatly expanded by the development of the two epicondylar flanges. Proximal to the distal edge of the bone, formed by the edge of the radial and ulnar condyles, there is a shallow triangular depression lying between the dorsal surfaces of the two epicondylar flanges. The anterior (preaxial) border of this hollow is sharper than the posterior (postaxial) border and is a continuation of the L.M.L. Anterior to this ridge lies the confluent ectepicondylar (radial epicondyle) and supinator flange, which in the Titanosuchia is pierced by the rounded ectepicondylar foramen, either vertically or obliquely. Distally this flange has a thickened truncated end, to which the extensor muscles were attached. The supinator part of this flange has a thin, sharp edge — thinner in the Tapinocephalia and Anteosauria than in the Titanosuchia. In the Titanosuchia the ectepicondylar

foramen pierces this flange either quite near its edge where it is thinnest, or deeper in through much thicker bone. In the first case the perforation is at right angles to the surface, whereas in the latter case the perforation is oblique, with the ventral exit situated further distally than the dorsal entry.

The entepicondylar flange is thicker than the confluent supinator and ectepicondylar flange. To its thick truncated distal end the strong flexors were attached. The slitlike entry of the entepicondylar foramen really lies somewhat proximal to the epicondylar flange proper on the dorso-postaxial or the postaxial surface of the shaft. The foramen perforates the bone obliquely so that its ventral exit lies further distally as well as ventrally.

The proximo-ventral surface of the humerus consists of a large hollowed out triangular surface (the bicipital fossa), which is bounded anteriorly by the large delto-pectoral crest, the proximal edge, formed by the processus lateralis, the caput humeralis and the processus medialis, and posteriorly by the thick posterior edge, to which the median head of the triceps was attached. In this view the delto-pectoral crest is seen to extend ventrally, from its origin at the processus lateralis, as an inclined strong sheet of bone terminating ventro-distally in the thickened corner for the insertion of the m. pectoralis. The pectoralis-corner is never knoblike as in the Pareiasaurs, but is thicker in the Titanosuchia than in the Tapinocephalia and Anteosauria. In *Jonkeria parva* the D.P.C. is particularly massive and short. In the Titanosuchia, with one exception, the pectoralis-corner is situated very far distally, whereas in the Tapinocephalia its distal extension is moderate to small, and in the Anteosauria small. From this corner the pectoral crest subsides into the surface of the shaft in postero-distal direction, abruptly in the Titanosuchia, but gently in the case of the Tapinocephalia and the Anteosauria.

The ventro-distal surface of the humerus is broad to very broad and consists chiefly of the capitellum or radial condyle which is large and massive in the Titanosuchia, but in the Tapinocephalia and Anteosauria it is a much smaller feature. The capitellum lies mostly in the pre-axial half of the distal surface and in the Titanosuchia it forms a large bulbous mass of bone stretching far to very far in proximal direction nearly to or even beyond the plane in which the entepicondylar foramen lies. It is well modelled with sharp borders in the Titanosuchia, whereas in the Tapinocephalia and Anteosauria the modelling is weaker and it is not bulbously swollen and never stretches far in proximal direction. The ulnar articular surface is not clearly demarcated from the radial condyle and simply forms the rounded part of the distal edge of the humerus. The lateral portions of the ventro-distal surface form the under surfaces of the ect- and entepicondylar flanges. The ectepicondylar flange is thin and has its edge bent downwards. In the Tapinocephalia and Anteosauria its upper end is separated from the surface of the shaft by a groove, and it is, in the absence of the ectepicondylar

foramen in these groups, along this groove that the radial nerve ran. The entepicondylar flange is thick. The ventral opening of the entepicondylar foramen, through which passed the medial artery and nerve, is in the Tapinocephalia and Anteosauria a fairly narrow slit, but it is more oval in the Titanosuchia. In the Tapinocephalia and Anteosauria the entepicondylar foramen is always a considerable distance from the proximal edge of the radial condyle, whereas in the Titanosuchia the radial condyle in some forms extends so far in proximal direction that the foramen lies close to the proximo-postaxial edge of the condyle.

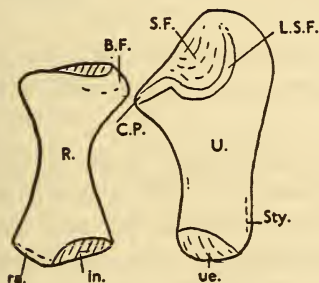
THE SHOULDER JOINT

From the description of the glenoid cavity and the shape of the caput humeralis it is clear that the shoulder joint was not a very efficient structure. A large amount of cartilage and strong ligaments were necessary to make the joint function at all well. Even so, any great forward disposition of the humerus must have taken the head of the humerus out of the socket. It would appear that in the Titanosuchia the humerus lay more horizontally than in the Tapinocephalia, where it was inclined obliquely downward towards the elbow.

RADIUS

The radius is not very well known. In this collection only 7 good radii are preserved. Hitherto the radius has been described in *Moschops* by

Diag. 3.



A Titanosuchian radius and ulna in dorsal view. B.F.—flange for the insertion of the biceps; C.P.—coronoid process; in.—facet for intermedium; L.S.F.—lip to sigmoid fossa; R.—radius; ra.—facet for radiale; Sty.—styloid flange; U.—ulna; Ue.—facet for the ulnare.

Broom (11) and Gregory (18). Of the radius of *Tapinocephalus* Broom (13) in 1928 says "the radius is broad and flat" and agrees with that of *Moschops* but is more massive. In 1929 Broom (14) described a radius of *Jonkeria* sp. and figured a right radius of "probably *Titanosuchus ferox*". In 1931 von Huene (21) gave a figure of a Deinocephalian radius. Byrne (16) figured the bone in *Moschoides* and I (4) figured the radius of a Moschopid in 1954.

In the larger Titanosuchians the radius is a large stout bone, but in some of the smaller forms it is relatively slender (length 190-318 mm.). The two ends are expanded, especially the proximal one in the larger forms. Both the ends and the shaft are oval in section. The proximal end is flat or

becomes convex towards the postaxial border, which abuts against the rim of the sigmoid facet of the ulna (but in *Keratocephalus* the whole proximal face is convex). On its postaxial corner there is a weak to strong flange (bicipital), whose edge fits into the hollowed surface of the ulna below the rim of the sigmoid facet. A similar flange is developed on the distal postaxial surface, where the radius fits against the ulna. The pre- and postaxial faces are deeply concave in the *Titanosuchia*, but the shaft is little constricted in *Keratocephalus* and some *Moschopids*. The preaxial edge is fairly sharp, whereas the postaxial edge is rounded. The distal end is fairly flat or quite strongly convex, and in some *Titanosuchia* shows a well developed facet for the intermedium and a lesser one for the radiale.

ULNA

In 1876 Owen (23) noticed as *Pareiasaurus* an ulna, which Seeley figured and, as Lydekker (22), considering it to be of *Tapinocephalus*, remarks "referred it in the abstract to *Titanosuchus*". This is undoubtedly a *Titanosuchian* ulna notwithstanding that Broom (14) also considered it to be of *Tapinocephalus*. The supposedly *Titanosuchus* ulna figured by Seeley (28) is really a tibia of a *Pareiasaurian*. The *Moschops* ulna was figured by Broom (11) and refigured by Gregory (18), and in Broom's (10) photo of the "*Tapinocephalus*" fore-limb a large *Titanosuchian* ulna is shown. In 1914 Watson (29) mentioned the ulna of *Phocosaurus* and Broom (13) mentions an ulna of *Tapinocephalus* and figured (14) part of an ulna of *Jonkeria crassus* and describes the ulna of *Jonkeria* sp. In 1931 von Huene (21) figured an imperfect ulna of a *Deinocephalian*. Byrne (16) figured the bone of *Moschoides* and I (4) figured a *Moschopid* ulna in 1954.

In our collection there are 15 ulnae, some without the distal end. In no case is there a pair and in only two cases have we a radius associated with an ulna.

The *Deinocephalian* ulna is fairly to very massive and short (length 258-402 mm.). Its proximal end is greatly expanded; the shaft is broad but flattened; the postaxial face is fairly straight, but the preaxial face is deeply concave; the distal end is only slightly more expanded than the shaft. Proximally the lateral corner is developed into a strong olecranon which is rugosely striated for the reception of the strong triceps muscle. Medially lies the large sigmoid face for articulation with the humerus; this surface is only shallowly concave longitudinally and it is continued on to the strong coronoid process; dorsally to the coronoid process the sigmoid face ends, in its medial part, in a concave rim, to which the outer edge of the head of the radius is applied, so that the sigmoid face is continuous with the proximal face of the radius to form a conjoined articulatory facet for the capitellum

of the humerus. The sigmoid face has a more or less distinct ridge running proximo-distally so that two faces, inclined at an obtuse angle to each other, can be distinguished; the dorsal part articulates with the humerus when the limb is directed forwards, and the ventral part comes in play when the epipodium is rotated to the posterior position. The dorsal lip of the sigmoid face forms a more or less prominent rim, which is continued medially by the sharp edge of the head of the ulna. Lateral to this rim the dorsal surface of the ulna bears a longitudinal groove fading away distally on the shaft; on the ventral face there is a similar though deeper groove. The distal end is indistinctly divided into three facets; the central and larger facet is for the ulnare, the preaxial facet for the intermedium and the postaxial one for the weak pisiforme. Proximally of this facet for the pisiforme the postaxial edge of the ulna develops a sharp ridge, which apparently has the same function as a styloid process.

THE ELBOW JOINT

For all major movements the two bones of the epipodial move as a unit and the articulatory face formed by the ulna and radius is in the shape of a fairly large arc whose surface moves over the distal end of the humerus in flexion and extension. When the radius is rotated on its long axis the ulnar facet slides backwards or forwards against the distal face of the humerus. Extension is limited by the olecranon, for which little provision is made in the form of a shallow trochlear fossa.

MANUS

In the Deinocephalia the manus is insufficiently known. In the Moschopids the carpal formula is 3, 2, 5 Byrne (16) or 4, 1, 5 Boonstra (4) and the phalangeal formula 2, 3, 3, 3, 3 Byrne (16). In the Anteosauria I (4) recorded, in one specimen, a carpal formula 3, 1, 5 and the most unusual phalangeal formula 3, 3, 4, 4?, 2.

In the structure of the fore-limb the Deinocephalians show certain important advances beyond the Pelycosaur condition: in the humerus the proximal face has lost the elongated straplike articulatory face and the articulation is concentrated in a medially situated caput; the twist of the proximal and distal ends relative to each other is strongly reduced; the epicondyles are much reduced in size and there is never a separate supinator crest; the loss of the ectepicondylar foramen in all but the Titanosuchia; the distal position of the condyles makes a more upright disposition of the epipodial possible; the sigmoid face of the ulna forming a more widely open arc makes a greater

extension of the epipodial possible; the greatly laterally expanded delto-pectoral crest makes the area for the origin of the m. brachialis much greater.

C. *The Pelvic Girdle* (Diagram 4)

Owen (23), in 1876, was the first to examine elements of the pelvic girdle of a South African Deinocephalian. But, due to the confused labelling of the materials sent to the British Museum (N.H.), he mistakenly considered these to be Pareiasaurian, and also erroneously identified an ischium and pubis (B.M. 43525r) as parts of the pectoral girdle and humerus.

These pelvic elements were re-examined by Seeley (28) and made the type of a new genus, *Phocosaurus*. Lydekker (22) provisionally included this specimen in the genus *Tapinocephalus*, and Watson (29) refigured the pelvis.

In 1914 Broom (11) figured and described the pelvis of *Moschops*. This *Moschops*-material was re-examined by Gregory and Camp (17), Romer (25) and Gregory (18) and their restorations of the pelvis differ considerably from that of Broom.

Meanwhile Houghton (20) had published a photo of the mounted skeleton of *Struthiocephalus* showing the pelvis and on this Broom (15) based his reconstruction.

Broom (13) in 1928 figured an ilium and ischium under the name *Tapinocephalus atherstonei*, whereas they are in fact of a Titanosuchian.

In the following year Broom (14) described an ilium of *Jonkeria* sp. and another under the name *Dinosphageus haughtoni*; also an ischium under the name *Phoneosuchus angusticeps*. Both these have since been included in the genus *Jonkeria*.

In 1931 von Huene (21) figured and described the ilium of *Keratocephalus* and Broili and Schröder (6) an incomplete ilium and pubis of *Titanognathus lotzi*, which has since been included in the genus *Anteosaurus*. Finally Byrne (16) gave a brief account of the imperfect pelvis of *Moschoides*.

In our collection the pelvic girdle is represented in 18 specimens. In only six cases parts of the pectoral girdle are associated with parts of the pelvic girdle of the same specimen.

The pelvis is much lower than the pectoral girdle and the antero-posterior length of the pubo-ischiadic plate is also less than that of the coracoidal plate.

The three bones of each half are mostly not firmly united at the sutures and in immature specimens the centre of the acetabulum may still be cartilaginous.

The two halves, meeting in the median line, are weakly united, and in immature specimens a large lacuna is present, which may persist as a small opening even in older specimens; but in life would be closed with cartilage.

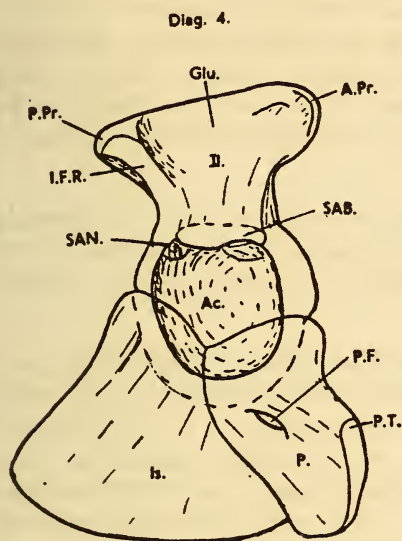
The junction of the pubes, particularly, is very weak, due to the eversion of the antero-ventral pubic edge. The ichial symphysis is stronger, but here the posterior median edges also diverge and no strong symphyseal carina is developed.

The attachment to the vertebral column is by a pair of very stout main sacral ribs, assisted by three posterior ribs, which are very much weaker and decrease in functional importance in posterior direction, and by a long slender anterior lumbo-sacral rib usually with a feeble attachment to the everted anterior iliac process. The main sacral rib lies above and in the same plane as the acetabulum — it is thus not pre-acetabular but supra-acetabular.

The acetabulum is large and roughly circular in outline; all three bones help in its formation, with the iliac part constituting a half to two thirds. The acetabulum faces mainly outwards except in the Anteosauria where it is directed considerably ventrally. It is fairly shallow but with strong raised rims for the attachment of the joint capsule and ligaments. Dorsally a very strong buttress,

stronger in the Titanosuchia than in the Tapinocephalia, overhangs the acetabulum (except in the Anteosauria), and this receives the main thrust of the femur. In its dorso-posterior corner, just posterior to the edge of the buttress, lies the large supra-acetabular notch.

The ilium is constricted above its acetabular part to form a neck or shaft; above this the blade is antero-posteriorly elongated, with a fairly long anterior iliac process and a shorter and weaker posterior process. In the Titanosuchia the supra-acetabular part of the ilium is high, whereas in the Tapinocephalia it is low to moderate. This also applies to both the posterior and the anterior



The pelvis of a Titanosuchian in lateral view. Ac.—acetabulum; A.Pr.—anterior iliac process, more or less everted (lower in most Tapinocephalia); Glu.—area of origin of the ilio-femoralis (gluteus); I.F.R.—ilio-femoralis ridge (this lies more horizontally in most Tapinocephalia); Il.—ilium (lower in most Tapinocephalia); Is.—ischium (restored); P.—pubis; P.F.—pubic foramen; P.Pr.—posterior iliac process (lower and lying more horizontally in most Tapinocephalia); P.T.—tuberculum pubis; S.A.B.—supra-acetabular buttress; S.A.N.—supra-acetabular notch.

processes. The anterior process is everted, weakly in most *Tapinocephalia* and strongly in most *Titanosuchia*. The posterior process extends further posteriorly in the *Tapinocephalia* than in the *Titanosuchia*, and in the former lies more horizontally and in the latter more upright. On the posterior edge of the posterior process an everted or folded-over ridge is developed, presumably for the origin of the ilio-fibularis muscle. This ridge lies horizontally in nearly all the *Tapinocephalia*, where it forms a sharp to rounded postero-ventral edge, whereas it lies much vertically in the *Titanosuchia*, where it forms a rounded to swollen thickening anterior to the posterior edge of the ilium.

The upper iliac edge overhangs the area of origin of the m. ilio-femoralis (gluteus) in some *Tapinocephalia*. The gluteal area is shallow in the *Tapinocephalia*, but in some *Titanosuchians* it is deeply concave antero-posteriorly.

In dorsal view the outline of the upper iliac surface is roughly triangular. The apex, lying medially, is at a lower level than the outer iliac edge, which is fairly straight in the *Tapinocephalia*, but concave in the *Titanosuchia*. The apex represents a great thickening on the middle part of the inner surface of the ilium. The massive main sacral rib abuts against this thickening — more particularly to its anterior face. This sacral rib extends ventrally along the inner iliac face to a plane just dorsal to that in which the outer buttress lies. Posterior to the attachment of the main sacral rib there are three irregular depressions for the reception of the three weak posterior ribs, whose upper surfaces lie in the same plane as the upper surface of the main rib, but as they are weak the ventral extent of their contact with the ilium is small. On the inner face of the anterior iliac process there is an ill-defined area for the reception of the end of the lumbo-sacral rib. The inner face of the ilium, dorsal to the sacral ribs, afforded an area for the attachment of the axial muscles.

The ischium is only adequately known in the *Tapinocephalia*. Its antero-posterior length is fairly small. Except for its acetabular portion it is fairly lightly built. It forms the postero-ventral segment of the stout acetabular rim. From its junction with the ilium its postero-dorsal edge is thick but posteriorly rapidly decreases to a thin edge, without the development of an ischial tuberosity. Its ventral edge is curved so that posteriorly it is separated from its fellow by a triangular incisure. Similarly the anterior ends also do not meet, but here the opening between the ischia and pubes was closed by cartilage. The central part forms a fairly strong symphysial face. The ischia meet at an angle to form a V-shaped pelvic exit, and no carina is formed along the median line.

The pubis has its anterior corner strongly everted. From this corner to the acetabulum the upper border of the pubis is thickened to form a stout pubic ridge from which the pubo-tibialis muscle originated. The corner or the tuberculum pubis, for the insertion of Poupart's ligament, is strong. Below the pubic ridge there lies the oval pubic foramen. Owing to its eversion only the posterior part of the ventro-median pubic edge meets its fellow to form a very weak line of contact, and the antero-posterior length of the pubis is small. On the inner face it shows a quite distinct area from which the pubo-ischio-femoralis internus originated.

In the pelvis the Deinocephalia have advanced beyond the Pelycosaurian stage in that the pubo-ischiadic plate has been greatly reduced in length; the strong development of the anterior iliac process and the reduction of the posterior iliac process; in the development of a large circular acetabulum; and increased height and a greater width to the pelvic outlet.

It most obviously differs from the higher Therapsids in the retention of the simple pubic foramen and in the shortness of its pubo-ischiadic plate.

D. *The Hind-limb* (Diagrams 5 and 6)

THE FEMUR

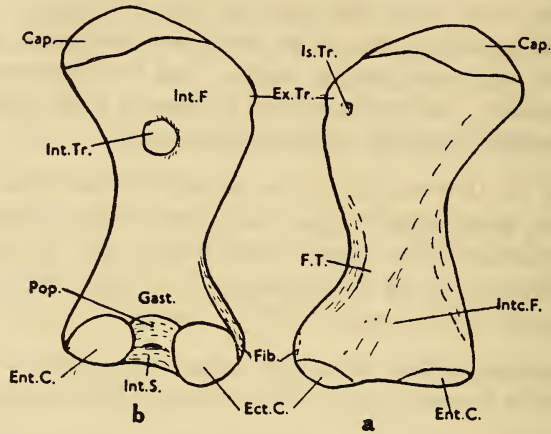
The first Deinocephalian femur from the Karroo to be described was a proximal half from Varsfontein (B.M. 43525t) first noticed by Owen (23) in 1876 under the name *Pareiasaurus bombidens* and figured by him (24) in 1880. Lydekker (22) referred this specimen to *Tapinocephalus*, and it will here be included in *Phocosaurus*.

Seeley (28) in 1889 figured (Pl. 19) a femur from Koedoeskop (B.M. 49368), which he considered to be associated, correctly I believe, with the type of Owen's *Titanosuchus ferox*. Broom (8) in his description of *Pelosuchus* mentions a femur, which he (15) figured in 1932. In 1914 Broom (11) figured a femur associated with the type material of *Moschops*, and figures of femora from this material were subsequently published by Gregory and Camp (17), Romer (25), Gregory (18) and Broom (15).

The femur of *Pnigalion* was figured by Watson (29) in 1914, and in the following year Broom (12) mentions that femora are associated with the type of jaws of *Moschognathus* and these were figured by Gregory (18). The femur of *Struthiocephalus* is shown in Haughton's (20) photo of the mounted skeleton. In 1928 Broom (13) figured a femur he thought to be of *Tapinocephalus*, but which in the sequel is shown to be of *Jonkeria*, and in the next publication (14) a femur of *Jonkeria* sp. In 1931 von Huene (21) figured the femur of *Keratocephalus* and Broili and Schröder (6) figured a distal end

of the Anteosaurian, *Titanognathus*. Byrne (16) gave figures of the femur of *Moschoides* and I (4) of *Micranteosaurus*.

Diag. 5.



The femur of a Titanosuchid, a. Dorsal view. b. Ventral view. Cap.—caput femoris; Ect.C.—ectocondyle; Ent.C.—entocondyle; Ex.Tr.—external trochanter; F.T.—origin of the femoro-tibialis; Fib.—facet for articulation of fibula; Gast.—origin of gastrocnemius; Int.C.—shallow intercondylar fossa; Int.F.—intertrochanteric fossa; Int.S.—intercondylar sulcus; Int.Tr.—internal trochanter; Is.Tr.—insertion of ischio-trochantericus; Pop.—popliteal fossa.

In the collection of the South African Museum there are 37 femora of which some are only represented by one of the two ends. Although there are about an equal number of femora and humeri it is noteworthy that only in 8 specimens there are preserved both a humerus and a femur of the same individual.

The femur of the Anteosauria differs so markedly from that of the Tapinocephalia and the Titanosuchia that in this general account of the Deinocephalian femur it is not considered, but is treated of separately in the systematic part of this paper.

The femur, always longer than the humerus, is a massive bone with very little of a shaft but with expanded ends. The proximal end is always wider than the distal end. There is a very little "twist" on the shaft so that the two ends lie in nearly the same plane, but the distal pre-axial condyle does lie a little more ventrally than the distal post-axial condyle. The post-axial condyle also lies a little further distally (where it lies much distally this appears to be due to postmortem deformation or is pathological). The shaft is always much broader than thick. In dorsal view the pre-axial border is more concave than the post-axial border. In pre-axial view the ventral border is more concave than the dorsal and the long axis is straight.

Proximally the caput femoris is terminal, but somewhat preaxially directed; it is antero-posteriorly elongated, thick preaxially, where it has an abrupt edge; but postaxially it tapers more or less gently towards the external trochanter from which it is sometimes separated by a slight notch; in its preaxial part the caput is moderately convex. The caput is much smaller than the acetabulum — its dorso-ventral diameter being about a third to a quarter of that of the acetabulum.

The external trochanter lies far postaxially to form the proximo-postaxial corner of the femur; from here the postaxial edge of the bone sweeps inwards with a fairly straight edge to the shaft and then more or less sharply outwards again to form the outer border of the ectocondyle. On the dorsal surface just preaxial to the external trochanter some femora have a slight pit, where the ischio-trochantericus muscle was presumably inserted.

The internal trochanter (sometimes not evident) is a rounded or oval tubercle, sometimes very prominent, lying on the ventral surface, well away from the preaxial border so that the intertrochanteric fossa lies well postaxially.

The distal articulatory facets for the tibia lie far distally and face only little ventrally; the outer facet is slightly larger than the inner and lies a little further distally. The two facets are separated by a deep and wide intercondylar sulcus, which proximally has a sharp ridge separating it from the popliteal fossa, and distally passes over into a shallow intercondylar notch; a rounded depression in the proximal part of the intercondylar sulcus presumably housed the quadriceps tendon.

The dorsal surface of the femur shows few prominent features; the intercondylar fossa is very shallow; from the outer condyle an oblique ridge runs in the direction of the caput femoris; between this ridge and the external trochanter the ilio-femoralis muscle has a large area of insertion; the femoro-tibialis originated from the middle part of this ridge.

On the postaxial face of the ectocondyle lies the weakly modelled surface to which the bipartite head of the fibula articulated.

The Deinocephalian femur has advanced beyond the Pelycosaur stage by the breaking up of the Y system of ridges; lack of a 4th trochanter; decreased "twist" on the shaft; the distal position of the condylar facets, but with the ectocondyle nearly in the same plane as the entocondyle and with a larger articulatory face. The widening of the whole bone and the flattening of the shaft is apparently a secondary approach to the Pareiasaur condition. It differs from the higher Therapsids in the great width and the lack of a long distinct shaft and the caput is not turned antero-dorsally.

THE HIP-JOINT

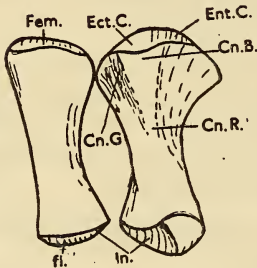
The Deinocephalian hip-joint is a very ill-fitting joint. The elongated caput femoris requires for its rotation on its long axis the very large circular

acetabulum in which it fits very insecurely so that the strong iliac buttress is required to prevent its dislocation when the thrust is transmitted. The femur in transmitting the thrust would lie obliquely with its distal end considerably lower than the caput and it would have great, but not very secure, possibility for antero-posterior movement. A very strong capsule and ligaments would be required to strengthen the joint.

THE TIBIA

Owen (23) mentions a tibia (B.M. R.1707) referred by him to *Pareiasaurus bombidens*. This tibia was figured by Seeley (28) who said "it may be new or it may be *Pareiasaurus* or *Tapinocephalus*". Considered by Lydekker (22) as *Tapinocephalus*, it probably really is *Titanosuchus*. Two other tibiae (one 47100) are mentioned by Lydekker as probably *Titanosuchus* or allied form.

Diag. 6.



A Titanosuchid tibia and fibula in dorsal view. Cn.B.—cnemial boss; Cn.G.—cnemial groove; Cn.R.—cnemial ridge; Ect.C.—facet for the outer femoral condyle; Ent.C.—facet for the inner femoral condyle; Fem.—proximal facet on fibula for articulation with outer surface of the ectocondyle; fi.—facet for the fibulare; in.—facet for the intermedium.

The tibia of *Moschops* was figured by Broom (11) and refigured by Gregory (18). In 1914 Watson (29) mentions a tibia as part of the type material of *Phocosaurus* and stated that the tibia of *Titanosuchus* "does not differ essentially from that of the *Tapinocephaloids*". In Houghton's photograph (20) a tibia of *Struthiocephalus* can be seen.

In 1928 Broom (13) figured a tibia, which I believe to be *Jonkeri*, as that of *Tapinocephalus atherstonei*, and, in the following year, he (14) figured the tibia of *Jonkeria truculenta* and noticed that of *Jonkeria* sp. In 1931 von Huene (21) figured the tibia of *Keratocephalus* and Byrne (16) in 1940 that of *Moschooides*.

In the collection of the South African Museum the tibia is represented by 17 more or less complete bones. It is remarkable that so many more tibiae than radii should be preserved. Only in one case both right and left

tibia of the same animal are present. In seven cases we have a tibia with a fibula in the same specimen.

The tibia is in size medium to large and fairly to very massive with strongly expanded ends and a robust shaft. The length varies from 180-355 mm. On its dorsal surface there is a very strong cnemial protuberance for the insertion of the tendon of the femoro-tibialis and associated muscles. This boss extends distally as a rounded ridge, which fades out on the shaft before reaching the middle of the bone. Postaxially of the cnemial ridge lies a fairly shallow groove bounded further postaxially by a weak ridge lying parallel to, but is much weaker than the cnemial ridge. The proximal expansion flares out preaxially as does also the distal expansion so that the preaxial border is deeply concave. The proximal expansion flares out less postaxially, but the distal expansion flares out abruptly postaxially.

The proximal surface is essentially triangular in outline with the apex formed by the massive cnemial boss. Above the cnemial eminence the surface is convex, but this flattens out towards the ventral corners, with the formation of a low indistinct ridge separating these two flattened faces. The preaxial face is greater than the postaxial one and they correspond to the two condylar faces of the femur. In a tibia of *Struthiocephalellus* a high ridge separates two concave faces.

The distal surface is strongly convex for the two-thirds of the surface lying preaxially; the postaxial part is flattened and tends to be concave.

The ventral surface is separated from the postaxial face by a strong ridge and is furthermore indistinctly divided into two parts by a ridge running obliquely, with its distal end lying preaxially; the upper part receives the long ventral muscles and the lower the short ventral muscles.

THE FIBULA

The fibula has hitherto been described by Seeley (28) in *Titanosuchus* and this identification is probably correct, although Broom (14) does not think the bone is a fibula at all; in *Moschops* by Broom (11) and refigured by Gregory (18); seen in Haughton's (20) photograph of *Struthiocephalus*; *in errore* by Broom (13) for *Tapinocephalus* and (14) in *Jonkeria truculenta* and *Jonkeria* sp. and finally by Byrne (16) in *Moschoides*.

In the collection described here there are 16 fibulae, of which only a couple are not very well preserved.

Although the weakest of the major limb-bones the Deinocephalian fibula is still a stout bone (length 220-345 mm.). The proximal expansion is great and moderately to very massive; the distal end is somewhat less expanded, but still quite strong; the postaxial edge is rounded and is in outline fairly straight, whereas the preaxial border is deeply concave and this edge is sharp up to near the distal end where it becomes rounded, with a sharp ridge lying more ventrally; the shaft is long, fairly wide but

flattened, and there is very little "twist" on the shaft, but the distal end is bent down preaxially so that the two ends do not lie in the same plane.

The proximal facet is convex in section and occupies the whole of the proximal end; although terminal it faces ventrally; in outline it is reniform with the hilus due to a hollowing out of the ventral edge; a thickening on the medio-dorsal surface near the head was for the insertion of the ilio-fibularis muscle.

The distal facet is broad but flattened, convex, thicker preaxially and facing more preaxially; the tilted preaxial part articulating with the intermedium and the postaxial part with the fibulare.

THE KNEE JOINT

The thrust of the hind foot is along the long axis of the tibia and is transmitted to the two femoral facets meeting the proximal end of the tibia in an efficient joint. As the articulatory surfaces on the femur lie much distally and curve round dorsally the lower leg can be greatly extended to bring the long axes of the tibia and femur nearly in line. Rotation of the tibia on its long axis is well allowed for with the fibula sliding over the postaxial corner of the femur and distally carrying the foot with it. In the *Titanosuchia* the amount of the extension possible is thus much greater in the hind-epipodial than in the fore-epipodial.

THE PES

The *Deinocephalian* pes is but poorly known; in the *Titanosuchia* the proximal row of tarsals consists of an intermedium and fibulare; in the *Moschopids* (16) the tarsal formula is 2, 1, 4 and the phalangeal formula apparently 2, 3, 3, 3, 3; in a single *Anteosaurian* I (4) recorded a tarsal formula 2, 1, 5 and a phalangeal formula 2?, 3?, 3?, 4?, 2.

SYSTEMATIC DESCRIPTIONS

Deinocephalia

Sub-ordinal Characters of the Girdles and Limbs.

The pectoral girdle is structurally Therapsid, but comparatively large and massive and without an acromion; the cleithrum is splintlike or well developed; the interclavicle with its anterior spatulate end turned upwards; the three scapulo-coracoid elements not firmly ankylosed; there is no ossified sternum.

The humerus is structurally Therapsid but comparatively massive and with either one or two epicondylar foramina; the radial facet is either much distally or much ventrally situated.

The ulna has a massive olecranon.

The pelvic girdle is structurally Therapsid but large and massive; the pubo-ischiadic plate is short; the acetabulum large; there is only a simple pubic foramen; in most groups there is developed a distinctive ridge on the posterior edge of the posterior iliac process for the origin of the m. ilio-fibularis; the anterior pubic edge is everted; the symphysis is weak.

The femur, of typically Therapsid structure, is either short and massive or long and slender.

Tapinocephalia

Infra-ordinal Characters of the Girdles and Limbs.

The pectoral girdle is fairly light to moderately massive; the scapula is fairly low to low (310-530 mm.) with the upper part of its blade fairly narrow to fairly broad (120-270 mm.); the scapular head of the triceps originates from a low mound; the internal opening of the foramen supra-coracoideus does not open into or is connected by a groove to the subscapular groove; the glenoidal facet of the scapula is small or of medium size and faces little or not at all externally.

The coracoidal plate is fairly short or long antero-posteriorly; the pre-coracoid is fairly large, but fairly weak with a thin anterior border and a fairly strong dorso-posterior apex; the precoracoid excluded from the glenoid or just enters the rim; its outer face is only moderately convex.

The coracoid is small to medium, light to fairly strong with a fairly large glenoidal facet facing dorso-posteriorly and also much externally. Except near the glenoid the three bones of the scapulo-coracoid are weakly united suturally.

The clavicle is a medium-sized flattened bone with expanded ends and a slight waist.

The cleithrum is a weak splintlike bone.

The interclavicle is a moderately light bone, moderately expanded anteriorly with a long slender to fairly slender stem. A shallow groove receives the lower end of the clavicle.

The humerus is fairly light to moderately massive; it varies in size from small to large (length 276-588 mm.), but is never short and squat, and sometimes long and fairly slender; there is never an ectepicondylar foramen; the capitellum is weak to moderately strong and usually poorly modelled and it never extends proximally along the ventral face but remains situated

much distally; the processus medialis always lies far proximally, nearly in the same plane as the caput; the processus lateralis always lies far proximally; the proximal expansion is moderately great to great; the epicondyles are moderately to greatly expanded; the shaft is short to long, narrow to very broad; the ventral opening of the entepicondylar foramen is always slitlike.

The ulna is small and light to moderate and fairly strong, or is short, massive and squat.

The radius is long and slender or fairly short with strongly expanded ends.

In the manus the carpal formula is 4, 1-2, 5, and the phalangeal formula is 2, 3, 3, 3, 3.

The pelvis has a fairly long pubo-ischiadic plate; the iliac blade is low to only moderately high; the ilio-fibularis ridge has a fairly sharp edge and is only moderately strong and usually lies nearly horizontally; the anterior iliac process is only slightly to moderately everted; the posterior iliac process is fairly long and low; the outer iliac face is only slightly concave in antero-posterior direction.

The femur varies from fairly small to fairly large (length 276-468 mm.), light, moderate to fairly robust, sometimes short and squat; the internal trochanter undeveloped or forming an elongated tubercle situated well away from the preaxial border; the width over the external trochanter is small (95 mm.) to great (256 mm.), and without a notch.

The tibia is massive and short (232 mm. in length) or slender or moderate (length 180-270 mm.).

The fibula is light and slender (length 222-288 mm.).

In the pes the tarsal formula is 2, 1, 4, and the phalangeal formula 2, 3, 3, 3, 3.

Tapinocephalidae

Family Characters of the Girdles and Limbs.

The pectoral girdle is only moderately massive; the scapula is low, with its posterior edge fairly straight.

The humerus is fairly massive but fairly long.

The ulna is moderate and fairly long or it is massive and squat.

The iliac blade is low with both the anterior and posterior processes long and low; the ilio-fibularis ridge is strong and prominent.

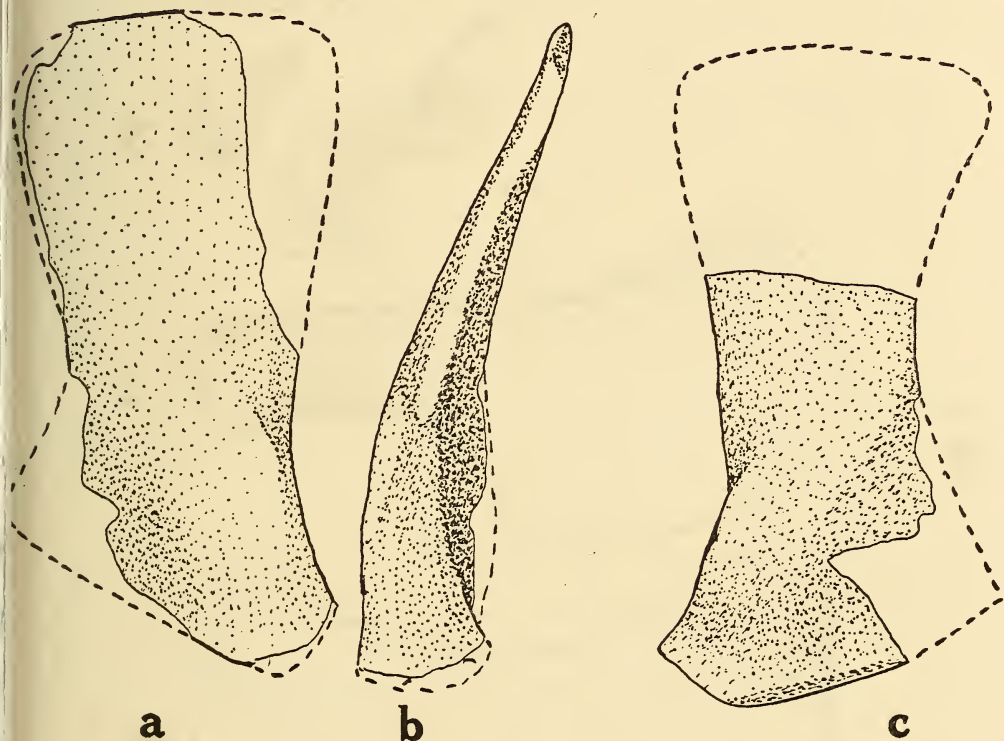
The femur is either fairly massive and fairly long or massive and squat.

The above statement on the characters of the girdles and limbs of the Tapinocephalidae is based on very inadequate material, as will become evident below.

Genus *Tapinocephalus* Owen (Figs. 1 a-b and 2)

In the collection of the South African Museum there is only one specimen in which there is an identifiable skull associated with some parts of the postcranial skeleton. This skull (S.A.M. 2344) is associated with two humeri and a scapula (S.A.M. 3355).

Fig. 1.

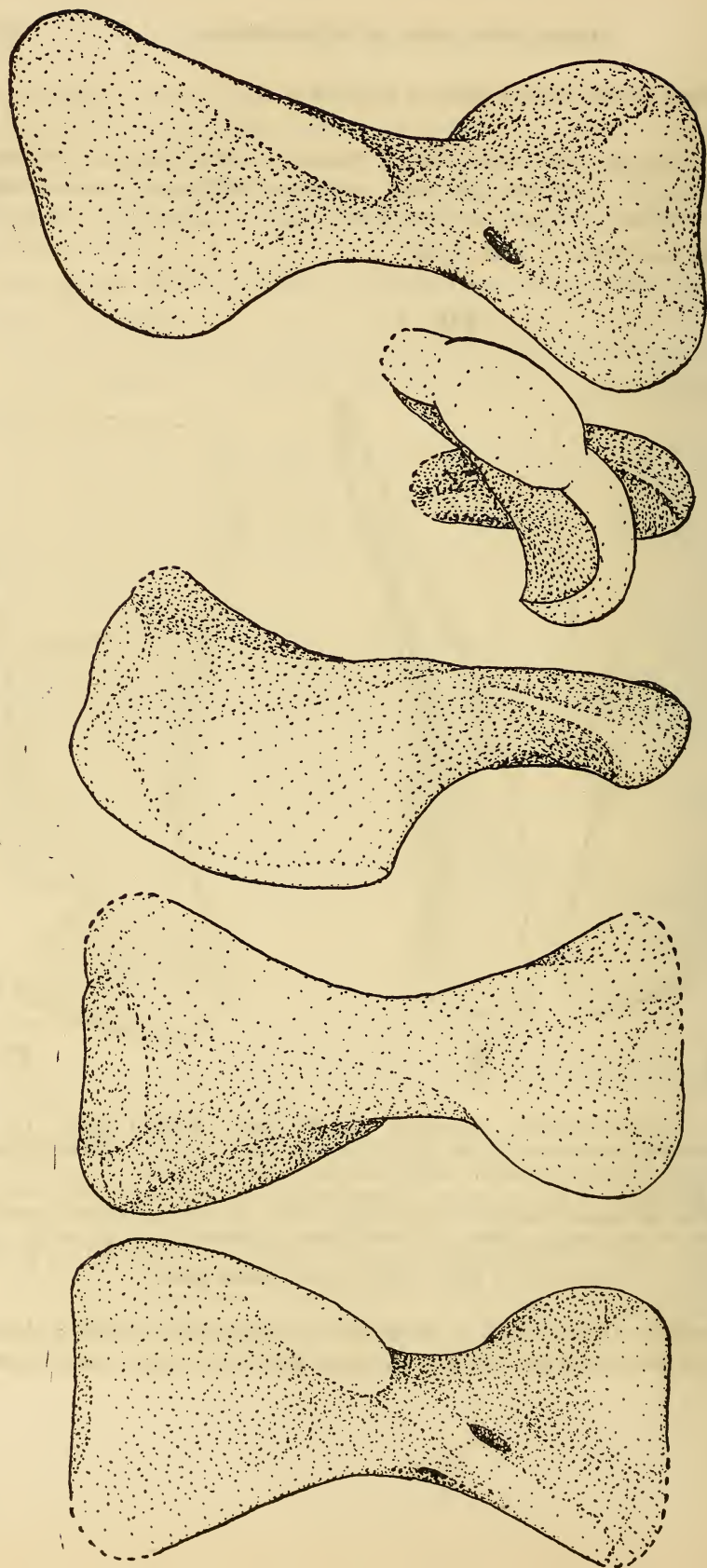


Scapulae. a. *Tapinocephalus atherstonei*, S.A.M. 3355. Lateral view. ($\times \frac{1}{8}$.)
 b. *Tapinocephalus atherstonei*, S.A.M. 3355. Posterior view. ($\times \frac{1}{8}$.) c. *Keratocephalus moloch*, S.A.M. 11937. Lateral view. ($\times \frac{1}{8}$.)

Note: All the figures in this paper are orthoprojections and not perspective drawings. In the girdles the figures labelled "lateral view" are of the bones in natural position projected on to the median plane, "anterior" and "posterior" are on to the one plane at right angles to the median plane and "dorsal" and "ventral" on to the other plane at right angles to the median plane.

The scapula (Fig. 1 a-b) is relatively low (530 mm.), with a broad blade (as reconstructed the width in its upper part is 270 mm.); the tricipital

Fig. 2.

**a****b****c****d****e**

Humeri of *Tapinocephalus atherstonei*. ($\times \frac{1}{4}$) a. S.A.M. 3355. Proximal view. b. S.A.M. 3355. Ventral view. c. S.A.M. 3355. Dorsal view. d. S.A.M. 5007. Ventral view. e. S.A.M. 3355. Anterior view. Note: In the humeri "ventral" and "dorsal" are projections on to the plane of the dorsal surface of the epicondyles, "anterior" is on to the axial plane at right angles to the above and "proximal" on the other plane at right angles to the first two.

ridge forms a strong but low mound; the internal opening of the foramen supracoracoideus does not open into the subscapular groove, which is very shallow indeed; the glenoidal facet is small and faces postero-ventrally and but very little externally; the upper part of the blade is fairly straight with little curvature to fit round the thorax.

The humerus (Fig. 2). Associated with the skull from Uitkyk (S.A.M. 2344), described by Haughton and correctly referred to *Tapinocephalus*, there is a fairly complete left humerus and a weathered proximal half of the right humerus (S.A.M. 3355). This association enables us to clear up the confusion which exists in regard to the *Tapinocephalus* humerus. The story of this confusion is as follows: In the first instance Owen (23) mistakenly referred the humerus B.M. 43525p from Varsfontein, Prince Albert, to *Pareiasaurus*. Lydekker (22), in correcting this obviously mistaken identification, himself erroneously referred it to *Tapinocephalus*. Broom (12), accepting Lydekker's identification, subsequently referred a specimen which he sold to the American Museum (A.M.N.H. 5611) to *Tapinocephalus*. Later Broom (13) figured a humerus (collection not stated) and states that this represents the true humerus of *Tapinocephalus* and at the same time refers B.M. 43525 to *Titanosuchus*. To make the confusion more confounded Broom then contradicts Seeley's (28) identification of B.M. 49369 as the humerus of *Titanosuchus* and refers this humerus to *Tapinocephalus*.

The Uitkyk humerus (S.A.M. 3355) associated with a *Tapinocephalus* skull, has no ectepicondylar foramen. In this feature it agrees with the known humeri of all the other members of the infra-order Tapinocephalia. Whereas all the humeri known to be associated with skulls classified as belonging to the infra-order Titanosuchia do have a well-developed ectepicondylar foramen. Thus quite apart from other features still to be considered below, the humeri A.M.N.H. 5611, B.M. 49369 and Broom 1928 (no collection or number given) must all belong to some genus of the Titanosuchia. B.M. 49369 should be left where Seeley put it, viz. in the genus *Titanosuchus* and A.M.N.H. 5611 in *Jonkeria* and Broom's 1928 humerus in *Scapanodon* and B.M. 43525 is the humerus of *Phocosaurus*.

The humerus of *Tapinocephalus* may be described as follows: very large (length 520-590 mm.); not very massive; proximal expansion great (width 276 mm.); distal expansion moderate (width 246-282 mm.); shaft fairly long and moderately thick (diams. 105 × 90 mm.); the delto-pectoral crest long, strong, terminating well proximal of the ventral opening of the entepicondylar foramen; caput oval in outline and lying in the same plane as the processus medialis and the processus lateralis; the processus medialis thus lies far proximally; the capitellum (radial condyle) is not well modelled, is weak, and lies much distally with its ventral part lying well distal of the plane in which the entepicondylar foramen opens; twist on shaft fairly

great (35° — 40°); the lateral median line is weak and the antero-dorsal ventral line is fairly weak; the entepicondyle is not greatly expanded and the foramen enters ventro-postaxially and leaves in a narrow ventral slit; the ectepicondyle is moderately expanded to form a thin unperforated curved plate with a sharp edge.

No other bones of the girdles or limbs in *Tapinocephalus* are known with any certainty, but below it will be seen that certain elements could probably be those of *Tapinocephalus*.

Tapinocephalus atherstonei Owen

The specific description is as for the genus.

Referred specimens in the S.A.M. collection:

S.A.M. 3355. An imperfect left scapula (Fig. 1 a-b), a good left humerus (Fig. 2 a-d) and the weathered proximal end of the right humerus, associated with a good skull. Uitkyk, Beaufort West. Low *Tapinocephalus* zone. Coll. Haughton.

S.A.M. 5007. An isolated good left humerus (Fig. 2e). Wilgerfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

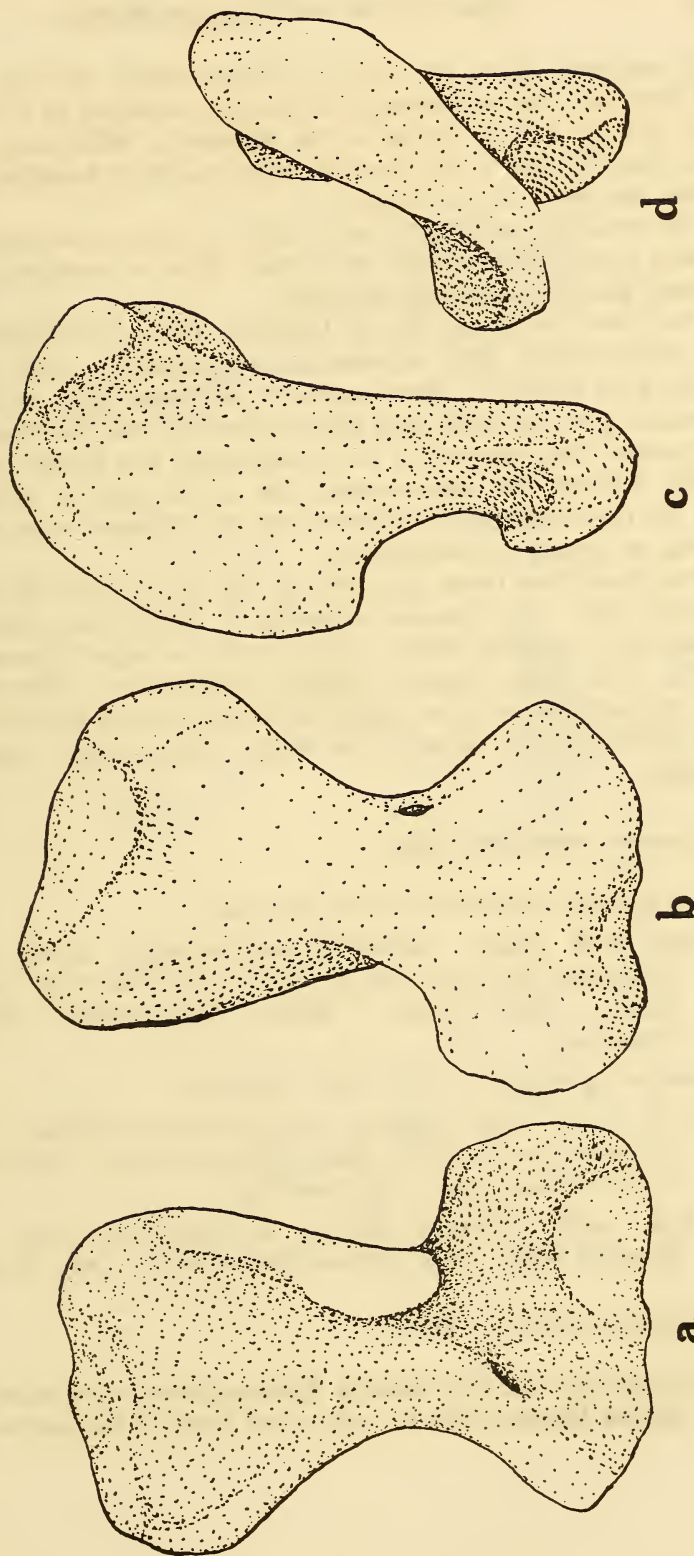
Genus *Phocosaurus* Seeley

This description is based mainly on the Varsfontein material in the British Museum (B.M. 43525), incorporating the accounts of Seeley (27), Lydekker (22) and Watson (29).

The pectoral girdle is large and massive; the scapula probably fairly low (lower than reconstructed by Watson, Fig. 11, which is given $\times \frac{1}{3}$, whereas it is in fact $\times \frac{1}{6}$); the scapular blade is fairly broad (240 mm.); the tricipital ridge is low; the glenoidal facet faces well externally. The precoracoid is inadequately known; "foramen opens into a distinct pit on the visceral surface" (Watson). The coracoid is massive with the facet facing much externally.

The humerus (Fig. 3) is large and massive (length 492 mm.); proximal (276 mm.) and distal (306 mm.) expansions large; shaft short and wide (diams. 168 $\times$ 96 mm.); the delto-pectoral crest very long and nearly reaching the plane of the ventral opening of the entepicondylar foramen; the caput is widely oval and lies in the same plane as the processus medialis and the processus lateralis, which also lies far proximally; the radial condyle is strong, fairly thick and well modelled, but situated much distally and not extending much proximally along the ventral face and thus well distal of the plane in which the entepicondylar foramen opens; the twist on the

Fig. 3.



Humerus of *Phocosaurus megischion*. ($\times \frac{1}{2}$.) B.M. 43525. a. Ventral view. b. Dorsal view. c. Anterior view. d. Proximal view.

shaft moderate (25°); the L.M.L. is fairly distinct and the A.D.V.L. is not prominent; the entepicondyle is strongly developed as a thick plate of bone and the ventral opening of the foramen is slitlike and situated well away from the edge of the bone; the ectepicondyle is developed as a greatly flaring thin sheet of curved bone

The ulna (see Seeley's Pl. 22) is short (320 mm.); the dorsal lip to the sigmoid face is fairly strong; the styloid ridge is prominent; width over coronoid process is moderate (204 mm.).

The pelvis (see Seeley, Pl. 21, Lydekker, Fig. 17 and Watson, Fig. 13). The pubo-ischiadic plate is short (as reconstructed $\pm 80\%$ of the total height of the pelvis); the ilium appears to have been fairly low in its supra-acetabular part and fairly long antero-posteriorly; the ilio-fibularis ridge on the posterior iliac process lies fairly horizontally and appears to have been thickly rounded; the antero-ventral edge of the pubis is strongly everted with the tuberculum pubis confluent with the thickened antero-ventral edge curving in towards the median line.

The femur (see Owen (24), Pl. 17, Fig. 8) is only represented by a proximal half. The proximal expansion is fairly broad (225 mm.); the preaxial face is fairly deeply concave with the caput directed well pre-axially; caput fairly massive; external trochanter not distinctly separated from the proximal face; the internal trochanter lies well in and is developed as a prominent oval tubercle; the shaft is fairly slender (diams. 112×72 mm.).

Phocosaurus megischion Seeley

The specific description is as for the genus.

Type: B.M. 43525. Incomplete coraco-scapulae, humeri, right ulna, incomplete pelvis and the proximal half of the right femur. Varsfontein, Prince Albert. Middle *Tapinocephalus* zone. Coll. Atherstone.

Referred specimens in the S.A.M. collection:

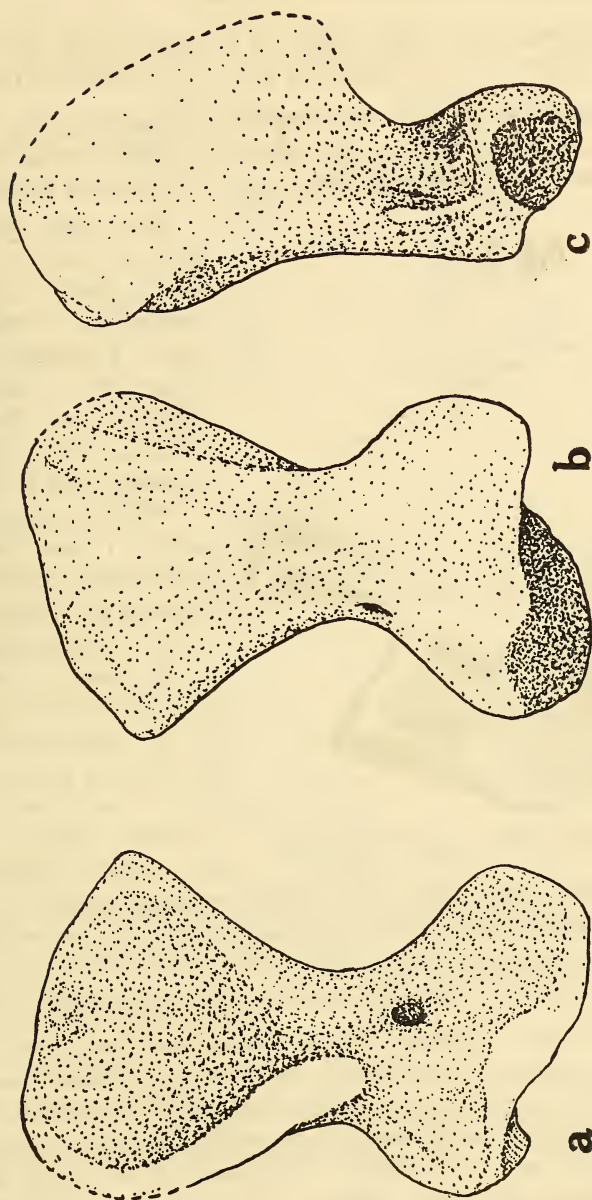
S.A.M. 11300. (Figs. 4 and 5.) A right humerus, showing a pathological lesion and an incomplete ilium. Deesweesfontein, Laingsburg. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11988. Proximal half of an isolated left femur. Boeteka. Beaufort West. High *Tapinocephalus* zone. Coll. Boonstra.

Genus *Keratocephalus* v. Huene

Although there are four skulls of *Keratocephalus* in the collection of the South African Museum there are only a few bones of the girdles and limbs,

Fig. 4.



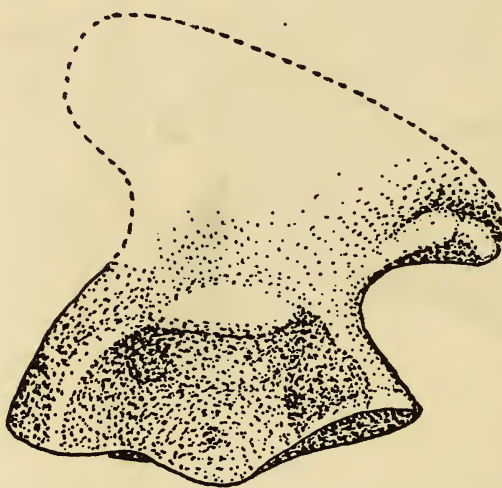
Humerus of *Phocosaurus megischon*. ($\times \frac{1}{2}$.) S.A.M. 11300. (Distal end showing erosion resulting from a pathological lesion.) a. Ventral view. b. Dorsal view. c. Anterior view.

but, together with von Huene's account of some bones in Tübingen, the following incomplete description can be given.

Of the pectoral girdle only a piece of a scapula (Fig. 1c) is known and this is very similar to the corresponding part of the scapula of *Tapinocephalus*.

In the collection there are two imperfect ulnae (Fig. 6a). The ulna is massive and squat (length $\pm$ 350 mm.); the styloid ridge is prominent; broad over the shaft and very broad over the coronoid process.

Fig. 5.



Ilium of *Phocosaurus megischion*. ($\times \frac{1}{6}$)
S.A.M. 11300. Lateral view.

long, but much shorter than the anterior process, with the ilio-fibularis ridge sharp and prominent and lying horizontally; the dorsal iliac edge is not folded over laterally; on the inner face of the anterior process there is a large face to receive a rib lying anterior to the main sacral rib.

The femur (see v. Huene's Figs.) is short (400 mm.) and broad; the width over the external trochanter is 256 mm.; the preaxial face is deeply concave with the caput much preaxially directed; the external trochanter is not demarcated from the proximal face, which extends far outwards from the caput; the internal trochanter developed as a prominent tubercle; the shaft is short and wide (diam. 132 $\times$ 84 mm.); the distal facets are terminal.

With only one crushed tibia in our collection (Fig. 6 e-f) and the one figured by von Huene, the *Keratocephalus* tibia appears to be massive

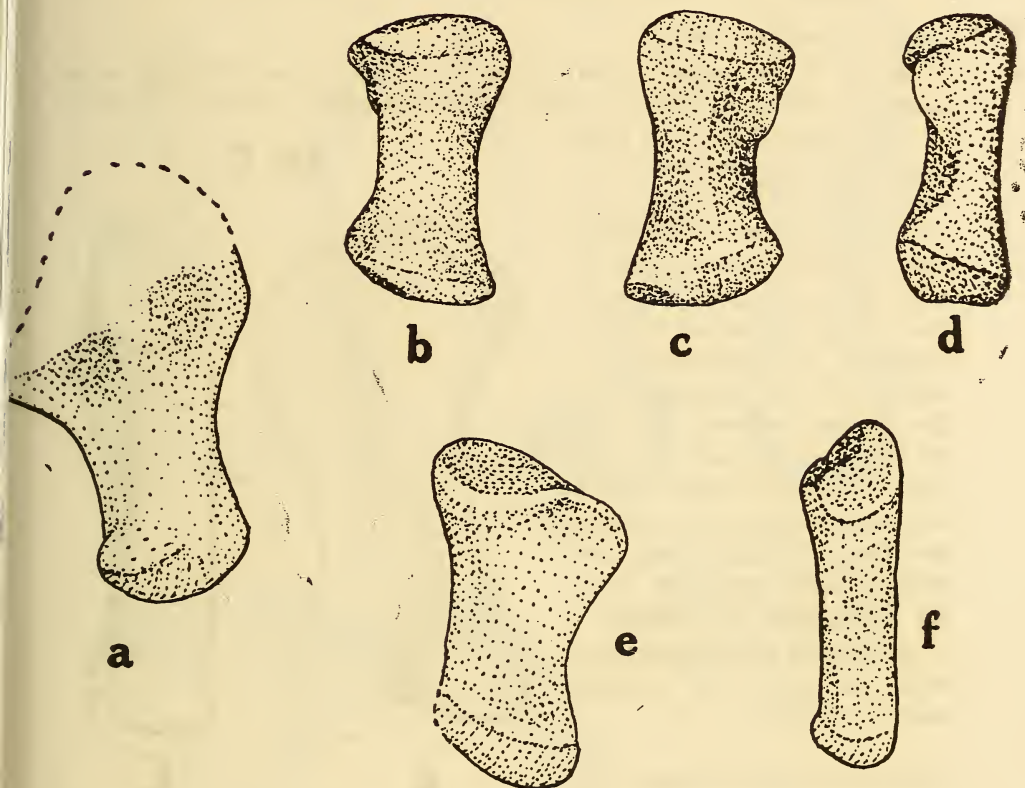
The only known radius (Fig. 6 b-d) is massive and squat (length 240 mm.); the ventral face is concave with a strong longitudinal ridge; the flange (for the insertion of the biceps) on the proximo-postaxial corner is strong; the proximal facet is convex.

With no pelvis in this collection I am extracting the characteristic features from von Huene's (21) account.

The supra-acetabular part of the ilium is low and very long (the height is only 52% of its antero-posterior length); the anterior process of the iliac blade is very long and low and is fairly strongly everted; the low posterior process is fairly

but short (length 232-276 mm.) with a broad shaft and a massive cnemial eminence.

Fig. 6.



Keratocephalus moloch. ($\times \frac{1}{4}$.) a. Ulna of S.A.M. 11937. Dorsal view. b. Radius of S.A.M. 11937. Dorsal view. c. Radius of S.A.M. 11937. Ventral view. d. Radius of S.A.M. 11937. Posterior view. e. Tibia of S.A.M. 8946. Dorsal view. f. Tibia of S.A.M. 8946. Posterior view.

Keratocephalus moloch von Huene

The specific description is as for the genus.

Type: Tübingen. An ilium, femur and tibia, associated with parts of the skull. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. v. Huene.

Referred specimens in the S.A.M. collection:

S.A.M. 8946. An imperfect left ulna and a crushed left tibia (Fig. 6 e-f), associated with a skull. Mynhardtskraal, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11937. An imperfect right scapula (Fig. 1c), an imperfect left ulna (Fig. 6a) and a good right radius (Fig. 6 b-d), associated with a skull. Buffelsvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra and Marais.

Genus *Pelosuchus* Broom

A part of the scapula preserved indicates a fairly close similarity to the scapula of *Keratocephalus*, as does also the incomplete weathered coracoid.

The femur (Fig. 7) is fairly short (420 mm.) and broad; the width over the external trochanter is 215 mm.; the preaxial face is deeply concave with the caput directed much preaxially; the external trochanter does not appear to be demarcated by a notch from the proximal face; the internal trochanter lies near the middle of the bone far away from the preaxial border and is a prominent and strong tubercle; the shaft is fairly strong and broad (diams. 132 × 80 mm.); the distal facets are terminal.

A distorted tibia appears to be stout and short with a strong cnemial eminence.

Pelosuchus priscus Broom

The specific description is as for the genus.

Type: S.A.M. 918. Part of a scapula, coracoid, a fairly good femur (Fig. 7)

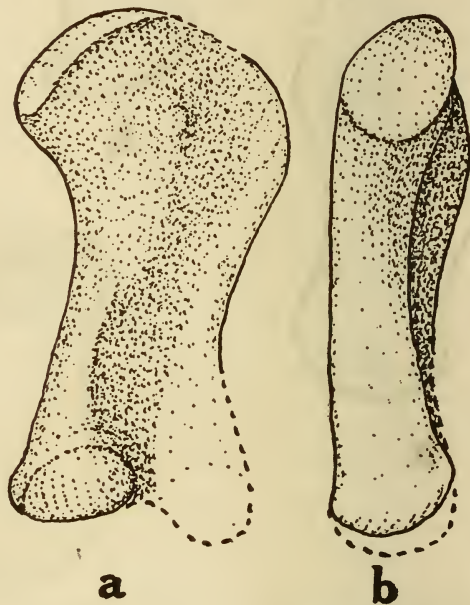
and distorted tibia, associated with a weathered dentary. Bokfontein, Prince Albert. Middle? *Tapinocephalus* zone. Coll. Cairncross.

Generically Undetermined Specimens:

S.A.M. 2753. A middle portion of a humerus (Fig. 12a) and the distal end of a femur. Viviers Siding, Beaufort West. Mid *Tapinocephalus* zone. Coll. Haughton and Whaits.

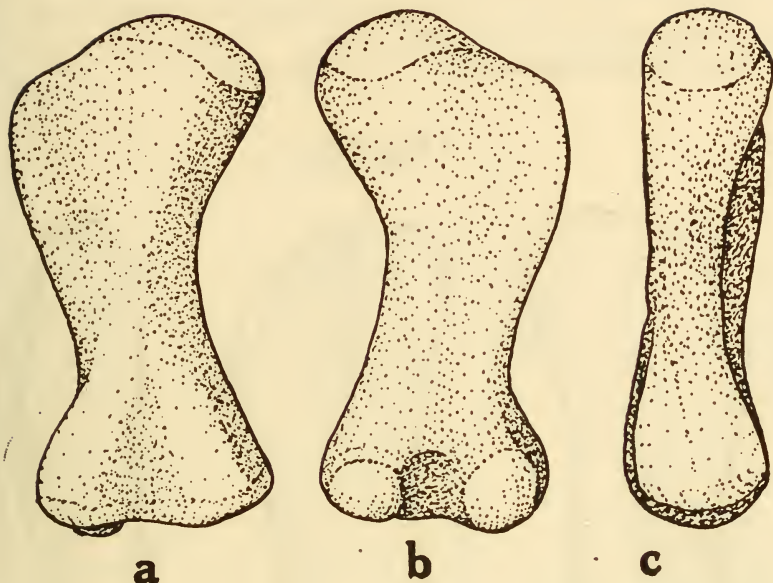
S.A.M. 9097. An isolated femur (Fig. 8). This is probably a femur of *Tapinocephalus*. Merweville Commonage. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 7.



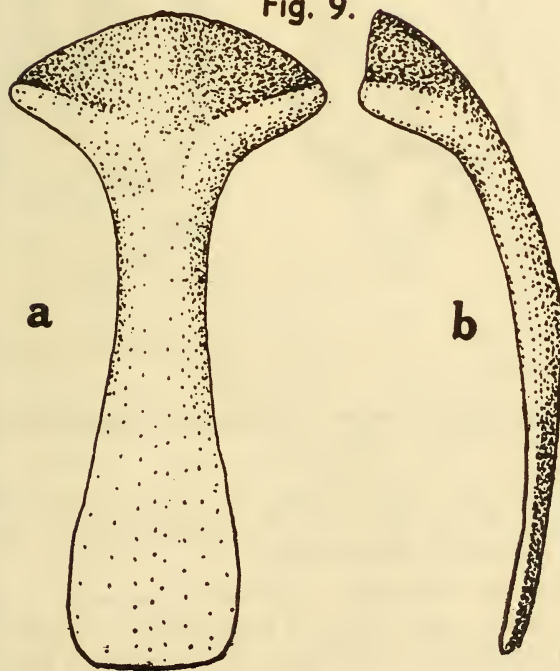
Femur of *Pelosuchus priscus*. ($\times \frac{1}{2}$) S.A.M. 918. a. Ventral view. b. Anterior view. Note: In the femur "dorsal" and "ventral" are projections on the plane in which the ventral faces of the condyles lie and "anterior" on to the axial plane at right angles to the above.

Fig. 8.



Above: Femur, probably of *Tapinocephalus*. ($\times \frac{1}{2}$.) S.A.M. 9097. a. Dorsal view. b. Ventral view. c. Anterior view.

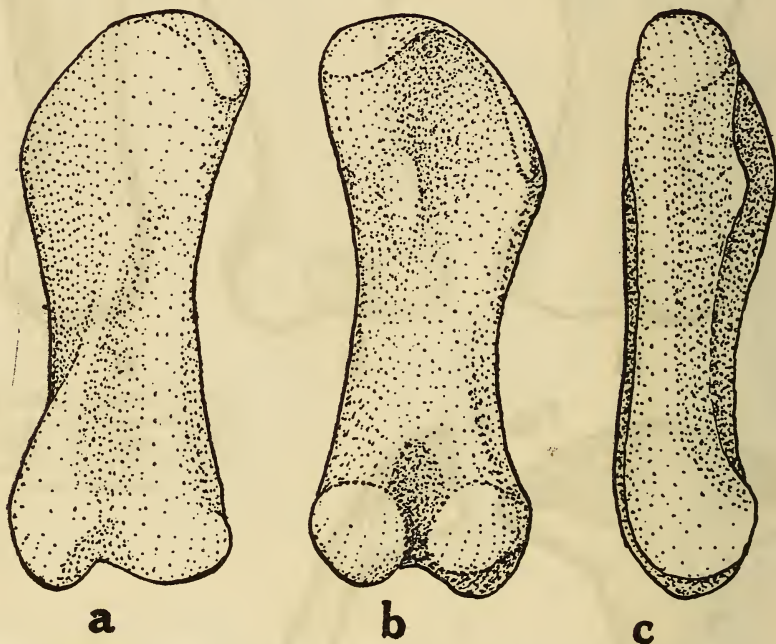
Fig. 9.



Left: Interclavicle of ? *Tapinocephalus*. ($\times \frac{1}{2}$.) S.A.M. 9153. a. Ventral view. b. Lateral view.

S.A.M. 9153. An interclavicula (Fig. 9) and a distorted femur (Fig. 10). The interclavicle has a long slender stem and the femur a ridgelike internal trochanter. These may represent a genus lying between *Tapinocephalus* and *Struthiocephalus*. Jacobskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 10.



Femur of ? *Tapinocephalus*. ($\times \frac{1}{2}$.) S.A.M. 9153. (Slightly distorted.) a. Dorsal view. b. Ventral view. c. Anterior view.

S.A.M. 9164. The middle portion of a humerus. Wakkerstroom, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11303. An isolated imperfect femur. Buffelsvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

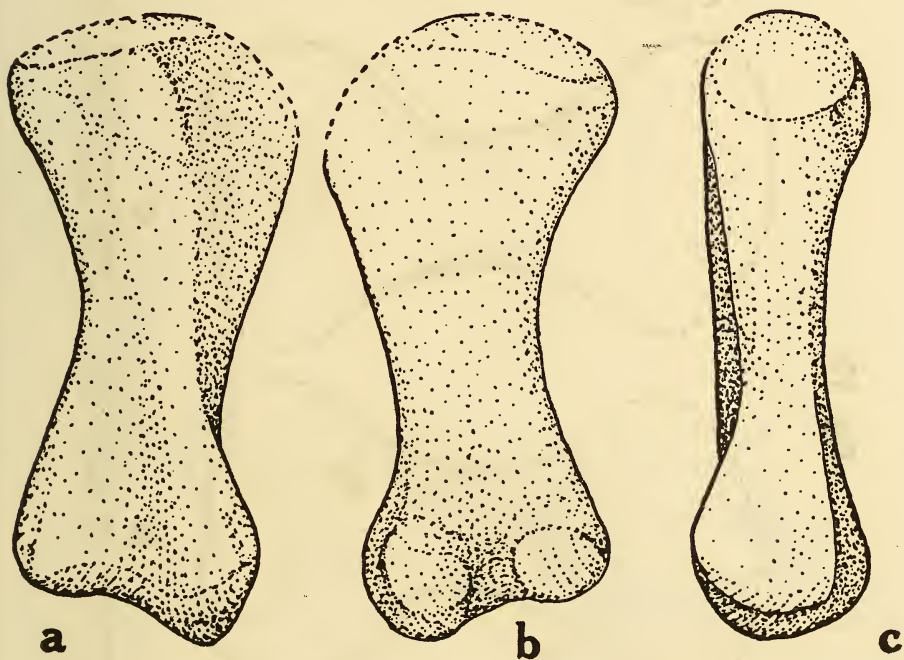
S.A.M. 11306. An isolated good femur (Fig. 11), which agrees well with the proximal end of the femur (B.M. 43525) which I am including in the type material of *Phocosaurus*.

The femur is quite robust and fairly long (498 mm.); the width over the external trochanter is moderate (234 mm.); the preaxial face is concave, with the caput directed well preaxially; the caput is massive (164 × 114 mm.); the shaft is fairly long and narrow (diams. 120 × 86 mm.); the tibial facets are

directed much distally and the postaxial epicondyle lies further distally than the preaxial epicondyle; the femoro-tibialis ridge is fairly strong and the area for the insertion of the ilio-femoralis is narrow.

Boesmansrivier, Beaufort West. Mid *Tapinocephalus* zone. Coll. Boonstra.

Fig. 11.



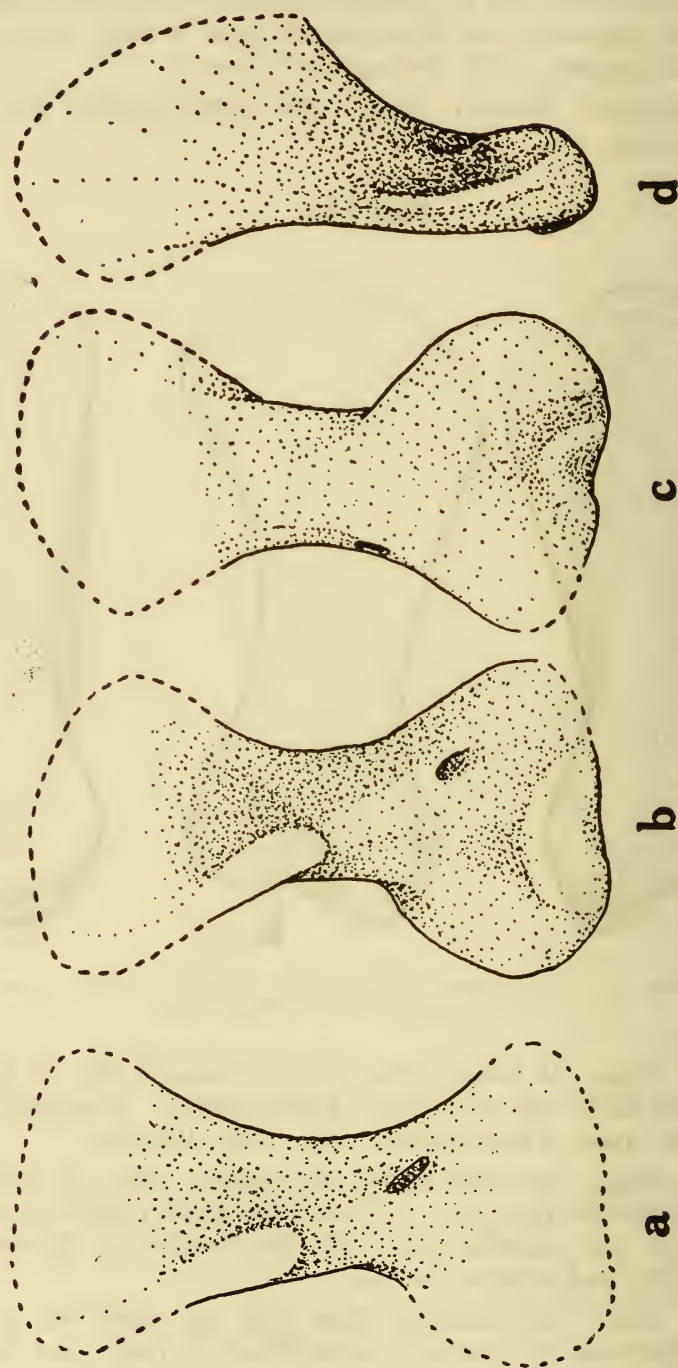
Femur of ? *Phocosaurus*. ($\times \frac{1}{4}$.) S.A.M. 11306. a. Dorsal view.
b. Ventral view. c. Anterior view.

S.A.M. 11702. An isolated distal end of a humerus (Fig. 12 b-d) which agrees fairly well with that of *Tapinocephalus*. Elandsberg, Sutherland. Low? *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11993. An isolated good left humerus (Fig. 13) with a long delto-pectoral crest and a well-modelled radial condyle as in *Phocosaurus*, but otherwise much like the humerus of *Tapinocephalus*. Locality and collector unknown.

S.A.M. 11997. An incomplete ilium (Fig. 14), distal end of a femur and the distal end of a radius, associated with a fairly good but as yet unprepared skull.

Fig. 12.



Humeri of ? *Tapinocephalus*. ($\times \frac{1}{2}$.) a. S.A.M. 2753. Ventral view. b. S.A.M. 11702. Ventral view. c. S.A.M. 11702. Dorsal view. d. S.A.M. 11702. Anterior view.

The ilium has most of its blade missing, but on the lower edge of the posterior iliac process there is a strong ilio-fibularis ridge lying horizontally; the acetabulum is very large but shallow.

In its unprepared state the skull cannot be definitely identified; it is certainly not that of *Keratocephalus* and in shape differs from that of *Tapinocephalus* and may thus very possibly be near *Phocosaurus*.

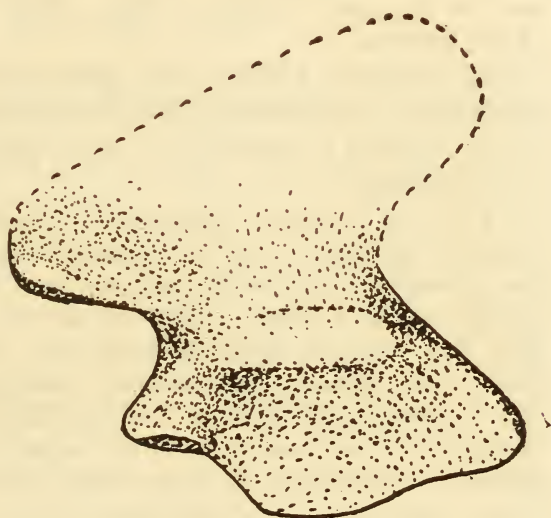
Locality and collector unknown.

Fig. 13.



Humerus of ? *Tapinocephalus*.
($\times \frac{1}{2}$.) S.A.M. 11993. Ventral
view.

Fig. 14.



Ilium of ? *Phocosaurus*. ($\times \frac{1}{2}$.)
S.A.M. 11997. Lateral view.

Struthiocephalidae

Family Characters of the Girdles and Limbs.

With much more material at our disposal than in the case of the *Tapinocephalidae* a much fuller account can be given of the girdles and limbs of the *Struthiocephalidae*.

The pectoral girdle is small to medium sized and light to only fairly massive.

The scapula is small and low (310 mm.) to fairly large and high (480-500 mm.) with the upper part of the blade expanded (120-230 mm.); its posterior border is fairly concave; the tricipital ridge is not very strongly developed; the subscapular groove is shallow and confluent with a groove lying in the visceral face of the precoracoid, dorsally of the inner opening of the supracoracoid canal; the glenoidal facet of the scapula is of medium size, concave and with a fairly well-moulded and raised external rim and it faces postero-ventrally but not externally.

The coracoidal plate is long antero-posteriorly. The precoracoid is fairly large and consists of a fairly thin plate of bone, but is thickened at the apex, which lies dorso-posteriorly of the outer opening of the supracoracoid foramen; its outer face is only very slightly convex; the supracoracoid canal is not directed very obliquely and its inner opening still lies in the precoracoid near the precoracoid-scapular suture, but has a groove dorsally confluent with the subscapular groove. The precoracoid is excluded from the glenoid and on the apex it carries a ridge which limits the anterior movement of the humerus.

The coracoid is a fairly strong element with a fairly large glenoidal facet which faces dorso-posteriorly and also externally.

No cleithrum is preserved but in all probability was a splintlike bone as in *Moschops*.

A pair of clavicles is preserved in *Struthiocephalus whaitsi*, but as is evident from Fig. 17 they have suffered from distortion, so that the right one appears to be a much squatter bone than the left one. The left clavicle, which I believe shows the natural form more truly, is a fairly light bone with an expanded lower end, which is applied to the outer face of the upturned interclavicular antero-lateral corner; the upper end has its anterior edge thickened and posteriorly there is a thin flange, which is applied to the outer face of the scapula; internally a ridge limits the posterior movement of the clavicle over the scapula.

The interclavicle is a strong bone with a fairly thick and long stem, which is, however, only moderately wide; the anterior spatulate end is considerably expanded and curves strongly upwards; the moderately hollowed surface for the reception of the clavicle is dorso-posteriorly bounded by the thickened raised edge of the bone; the upper surface of the stem has no median ridge for the lower edge of the coracoidal plate to abut against.

The humerus of this family varies considerably; in some cases it is fairly short and broad and in others long and fairly slender; in length it varies from small to fairly large (276?-475 mm.); the proximal expansion is moderate to large (156-270 mm.); the distal expansion is moderate to very large (174-288 mm.); the shaft is short to long and narrow to very broad

(width 84-125 mm.); the delto-pectoral crest is short to fairly long and it terminates, in all cases, well proximal to the plane in which the ventral opening of the entepicondylar foramen lies; the caput is narrowly to moderately narrowly oval; both the processus medialis and the processus lateralis lie far proximally, more or less in the same plane as the caput; the radial condyle is weak, not well modelled, and does not extend much proximally along the ventral surface and thus always lies well distal of the plane in which the entepicondylar foramen lies; the twist on the shaft is small to moderate (8° — 20°) and the one case in which it is 50° , this is undoubtedly due to postmortem distortion; the L.M.L. is weak to fairly strong; the A.D.V.L. is moderately to well developed; the entepicondyle is weak to moderate and the foramen slitlike; the ectepicondyle is little to greatly expanded.

The ulna is very inadequately known and is apparently fairly light and relatively long (258-366? mm.).

The radius is only known from a couple of ends.

The pelvis, hitherto unknown except for Haughton's (20) photograph of the mounted skeleton of *Struthiocephalus* and Broom's (15) restoration sketch based on it, is represented in the collection by three fairly well preserved specimens and a fourth with two iliae. The three bones of the pelvis are weakly united and the symphysis between the two halves is weak.

The pubo-ischiadic plate is relatively fairly long (the antero-posterior length is 90-102% of the height of the pelvis); the supra-acetabular part of the ilium is low (45-65% of its antero-posterior length) and long antero-posteriorly; the anterior process of the ilium is long and low and only slightly everted; the posterior process of the ilium is not much shorter than the anterior process, but is much lower, with its posterior edge lying nearly horizontally and partially everted to form a weak ridge (for the insertion of the m. ilio-fibularis), which also lies nearly horizontally; the dorsal iliac edge is folded over laterally to overhang and limit the gluteal area; on the inner face of the anterior iliac process there is a strong attachment of a rib anterior to the main sacral rib. In the pubis the upper part of the anterior edge is strongly everted to form an elongated tuberculum pubis, which is ventrally demarcated from the slightly thickened antero-ventral edge by a distinct step; in the median line the middle part of the pubis meets its fellow in a very weak pubic symphysis; the middle part of the ventral edge of the ischium is thickened to form a large sutural face for a fairly strong ischial symphysis; between the pubic and ischial symphyses there is a large quadrangular fenestra, in life filled with cartilage.

The femur of the *Struthiocephalidae* shows considerable variation: small (length 276 mm.), light and slender or medium sized (length 408-440 mm.),

fairly robust and broad or fairly long (468 mm.), fairly light and fairly slender; the width over the external trochanter is small (95 mm.) to great (210 mm.); the preaxial face is moderately to strongly concave with the caput only slightly or moderately preaxially directed; the external trochanter is not separated from the proximal face by any notch; the internal trochanter is undeveloped or forms a strong elongated tubercle, situated well away from the preaxial border; the shaft is fairly long to short and fairly slender to broad (55-125 mm.); the tibial facets are much distally directed; the m. femoro-tibialis originates on a fairly strong ridge; the ilio-femoralis area of insertion is narrow or broad.

The tibia is small (length 180 mm.) and slender to medium sized (length 240-270 mm.) and fairly slender with a well-developed cnemial ridge or eminence, and cnemial groove.

The fibula is light, fairly short to long and slender (228-288 mm.).

Genus *Struthiocephalus* Haughton

The pectoral girdle is of medium size and only fairly massive (total height as projected on to the median plane 696 mm.). The scapula is fairly massive and high (480 mm.); its posterior border is deeply concave. As the family description is based mainly on specimens of this genus refer back for additional characters of the pectoral girdle.

The humerus is preserved in two specimens with skulls associated, but in one, in addition to being juvenile, the humerus has undergone considerable postmortem distortion and in the other proximo-distal compression has shortened the bone with concomitant widening.

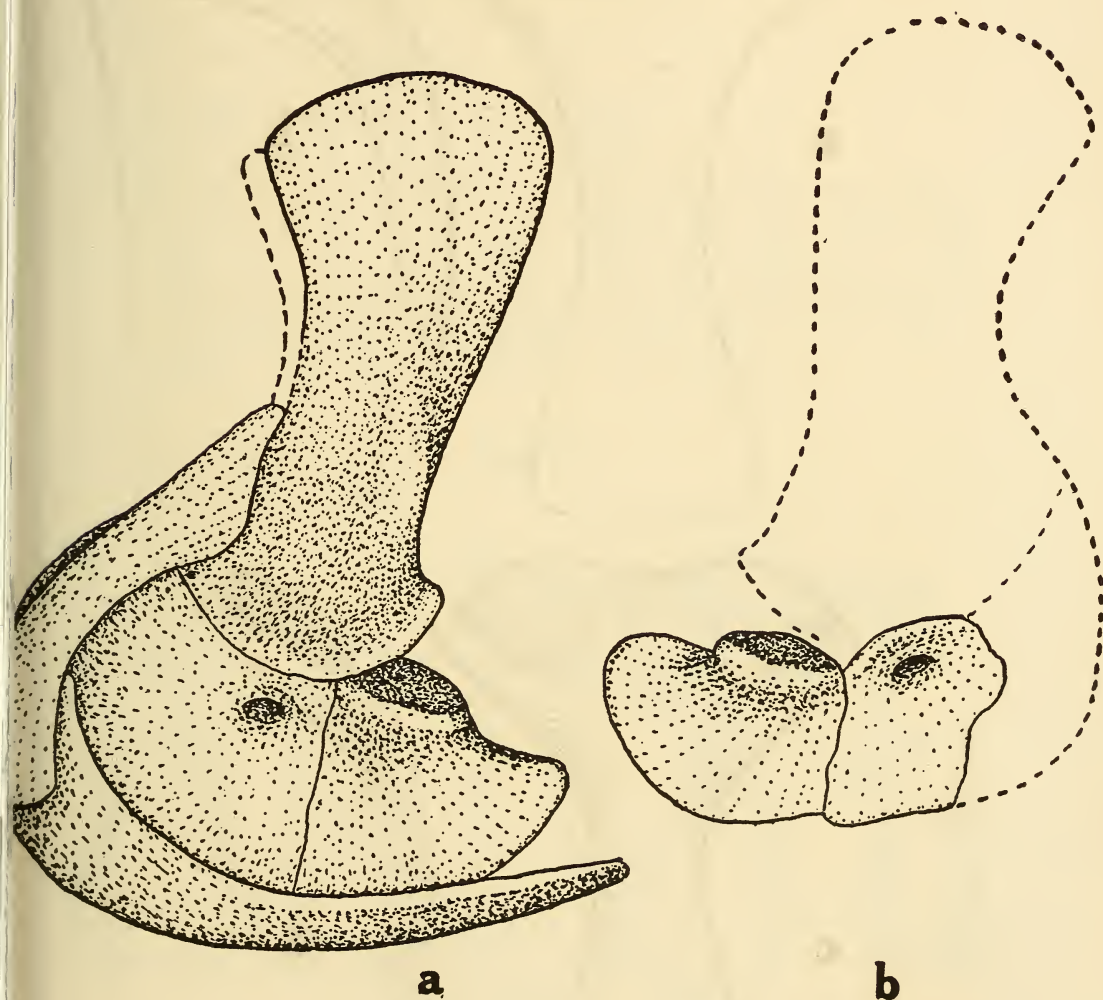
The humerus is fairly large (length 393-430 mm.) and fairly massive; the proximal expansion is large (270 mm.) and the distal expansion very large (288 mm.); the shaft is fairly long to short, moderately thick (diams. 102 × 60 mm.) to robust (diams. 126 × 60 mm.); the delto-pectoral crest is of medium length, terminating fairly far proximal of the ventral opening of the entepicondylar foramen; the caput is narrowly oval and lies slightly proximal to the processus medialis; the twist on the shaft is moderate (20°; in the deformed S.A.M. 11493 it is 50°); the L.M.L. is fairly strong; the A.D.V.L. is well developed; the entepicondyle is fairly strong with the foramen entering dorso-postaxially and leaving as a ventral slit; the ectepicondyle is greatly expanded as a thin sheet of bone.

The ulna and radius are inadequately known.

The pelvis is as described for the family; it may be noted here that in both specimens known, but in particular in the juvenile one, the ilium has not grown out to meet the other two bones in the central part of the

acetabulum, whereas the three bones meet in the pelvis of *Struthiocephalellus* which on account of its small size might have been considered a not fully grown *Struthiocephalus*.

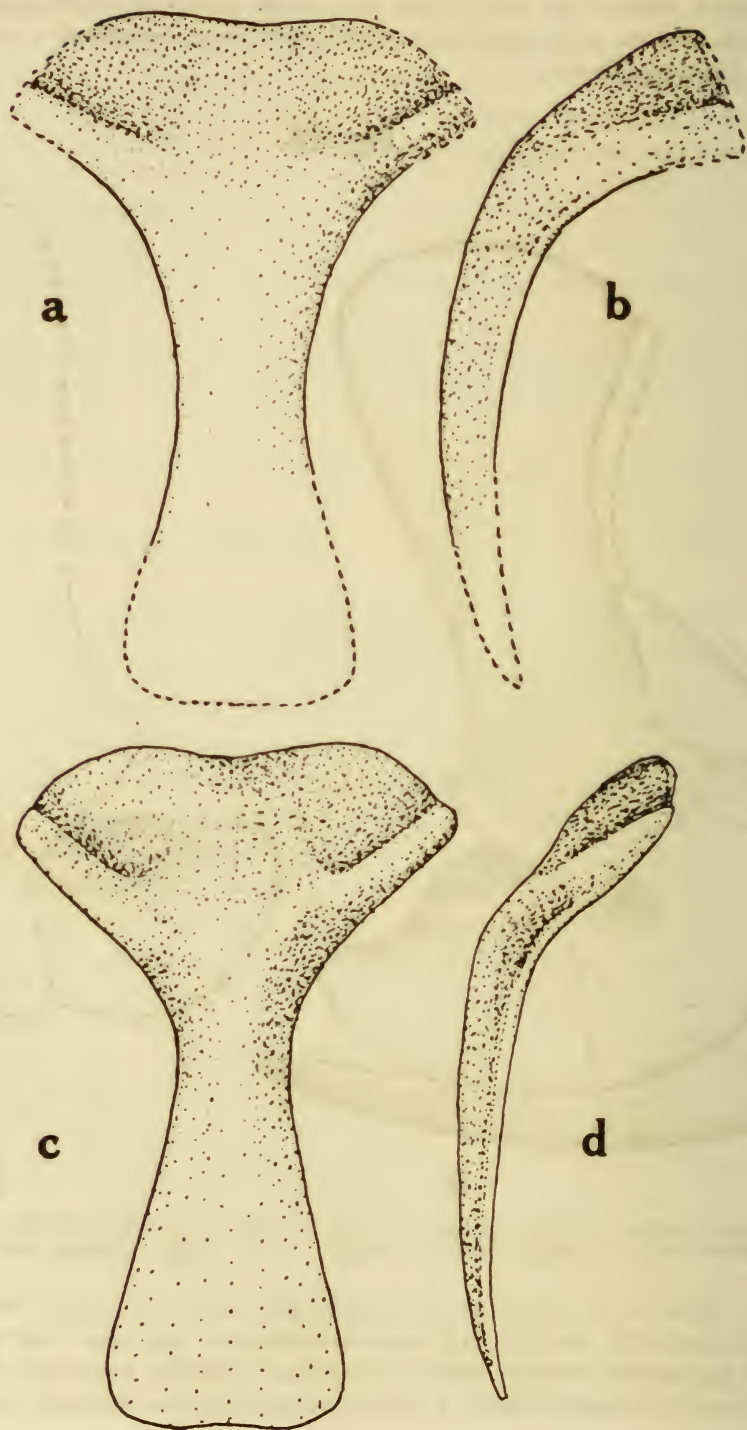
Fig. 15.



- a. Pectoral girdle of *Struthiocephalus whaitsi*. S.A.M. 3012. Lateral view. ($\times \frac{1}{4}$)
 b. Coraco-scapula of *Struthiocephalus whaitsi*. S.A.M. 11493. Lateral view. ($\times \frac{1}{4}$)

The femur is of medium size (length 440 mm.) and fairly broad and robust; the width over the external trochanter is 204 mm.; the preaxial face is moderately concave and the caput only slightly preaxially directed; the internal trochanter forms a fairly strong ridgelike tubercle; the shaft

Fig. 16.



Interclavicle of *Struthiocephalus whaitsi*. ($\times \frac{1}{4}$.)
 a. S.A.M. 3012. Ventral view. b. S.A.M. 3012.
 Lateral view. c. S.A.M. 11579. Ventral view.
 d. S.A.M. 11579. Lateral view.

short and broad (diams. 125×50 mm.); as preserved the postaxial tibial facet lies much distally; the ilio-femoralis area of insertion is broad.

The tibia appears to be fairly short (240 mm.).

The fibula is fairly short (230 mm.) but fairly robust with a deeply concave preaxial border.

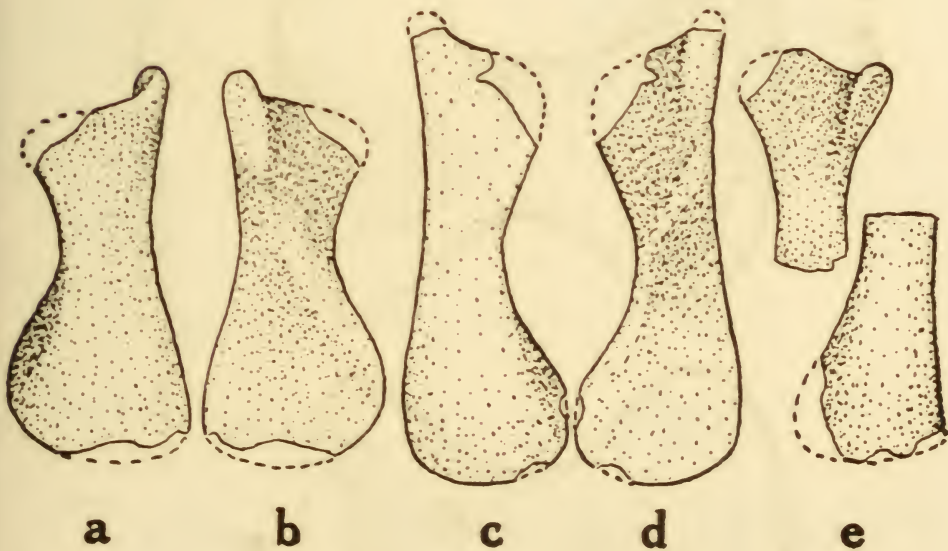
Struthiocephalus whaitsi Haughton

The specific description is as for the genus.

Referred specimens in the S.A.M. collection:

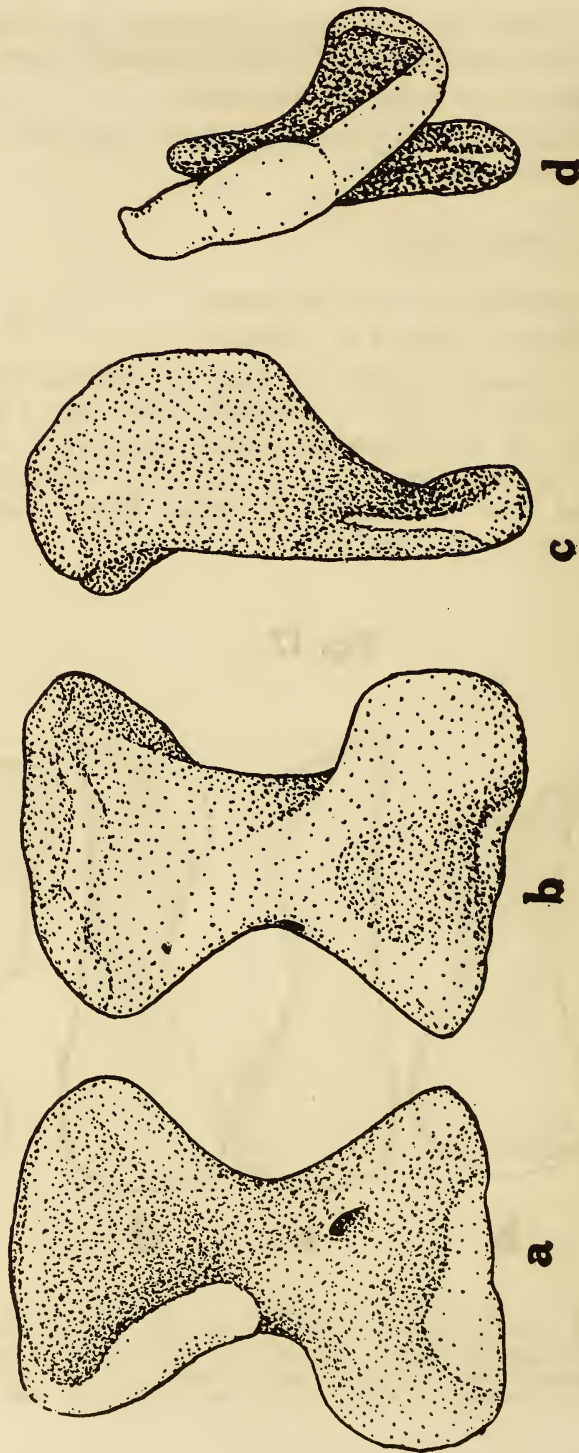
S.A.M. 3012. A nearly complete and fairly good pectoral girdle (Figs. 15a, 16 a-b and 17 a-d), a good humerus (Fig. 18), a fairly good pelvis (Fig. 19), two somewhat crushed femora (Fig. 20), a fair tibia (Fig. 21) and fibula (Fig. 22), associated with a fairly good but crushed skull. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

Fig. 17.



Claviculae. ($\times \frac{1}{2}$) a. *Struthiocephalus whaitsi*. S.A.M. 3012. Lateral view of right clavicle. b. *Struthiocephalus whaitsi*. S.A.M. 3012. Inner view of right clavicle. c. *Struthiocephalus whaitsi*. S.A.M. 3012. Lateral view of left clavicle. d. *Struthiocephalus whaitsi*. S.A.M. 3012. Inner view of left clavicle. e. *Moschops capensis*. S.A.M. 11972. Inner view of left clavicle.

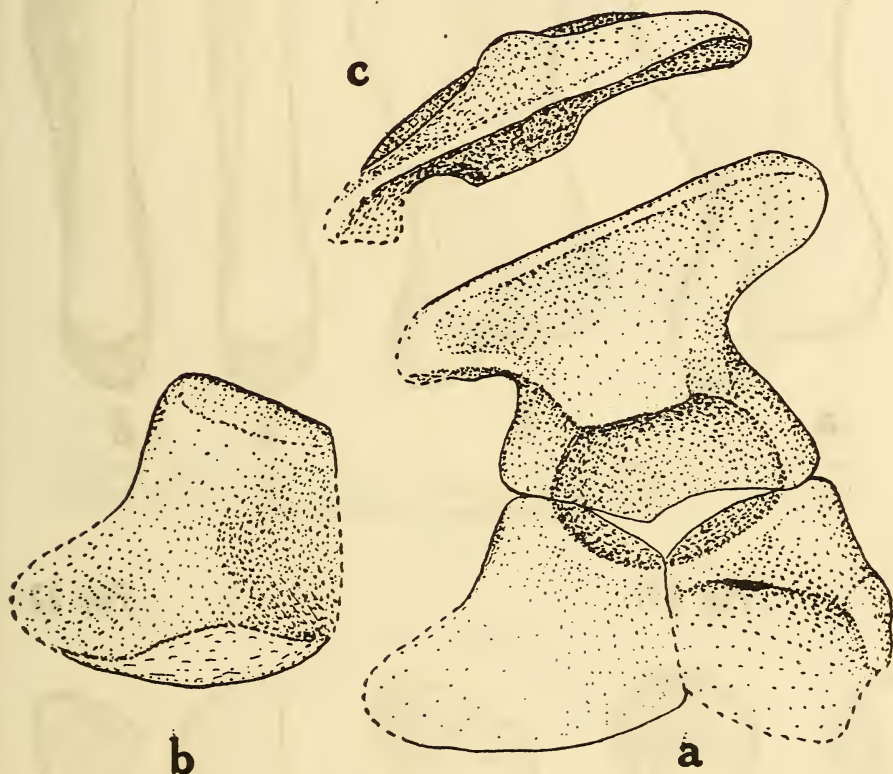
Fig. 18.



Humerus of *Struthiocephalus whaitsi*. S.A.M. 3012. ($\times \frac{1}{2}$.) a. Ventral view.
 b. Dorsal view. c. Anterior view. d. Proximal view.

S.A.M. 11493. A fair coracoidal plate (Fig. 15b), a distorted humerus (Fig. 23) and a good pelvis (Figs. 24 and 25), associated with a fairly good skull. Juvenile. Mynhardtskraal, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 19.

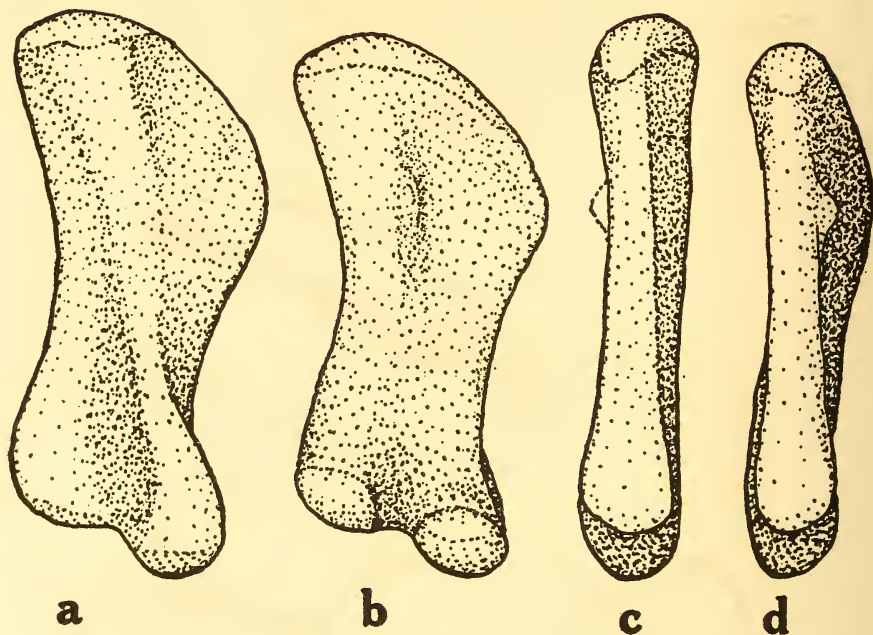


Struthiocephalus whaitsi. S.A.M. 3012, ($\times \frac{1}{4}$). a. Pelvis in lateral view.
b. Ischium in inner view. c. Ilium in dorsal view.

S.A.M. 11572. A fair interclavicle, most of both coracoidal plates and the proximal ends of both scapulae (Fig. 26). Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

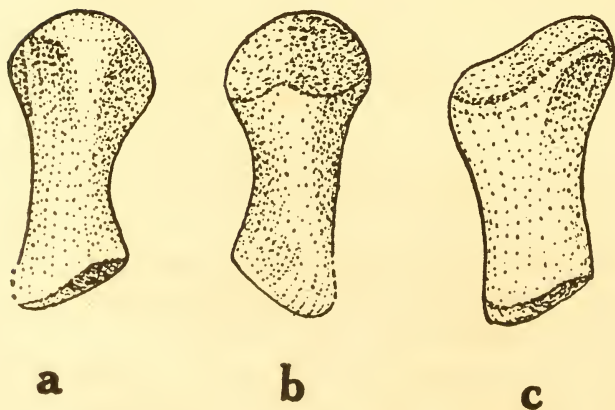
S.A.M. 11579. A good proximal two-thirds of a humerus, a good precoracoid and a good interclavicle (Fig. 16 c-d). Buffelsvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 20.



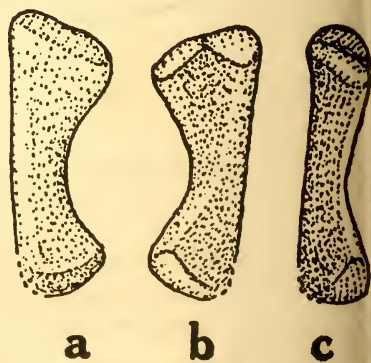
Femora of *Struthiocephalus whaitsi*. S.A.M. 3012. ($\times \frac{1}{4}$.) a. Left femur in dorsal view. b. Right femur in ventral view. c. Left femur in anterior view. d. Right femur in anterior view.

Fig. 21.



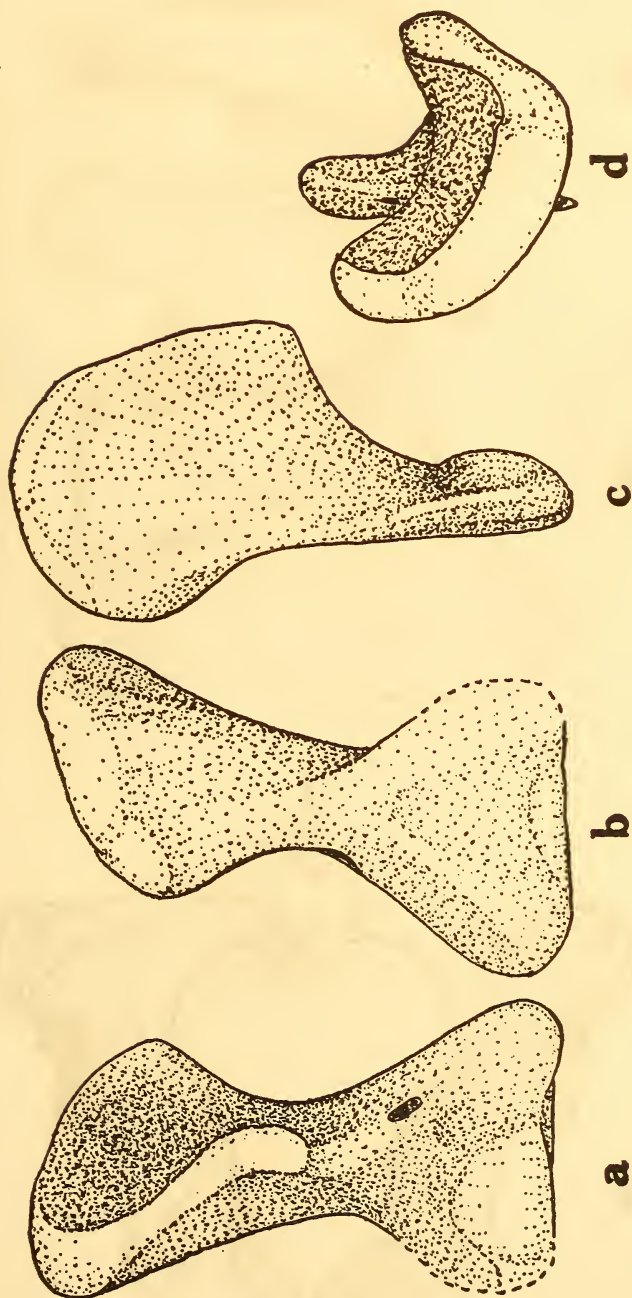
Tibia of *Struthiocephalus whaitsi*. S.A.M. 3012. ($\times \frac{1}{4}$.) a. Dorsal view. b. Ventral view. c. Posterior view.

Fig. 22.



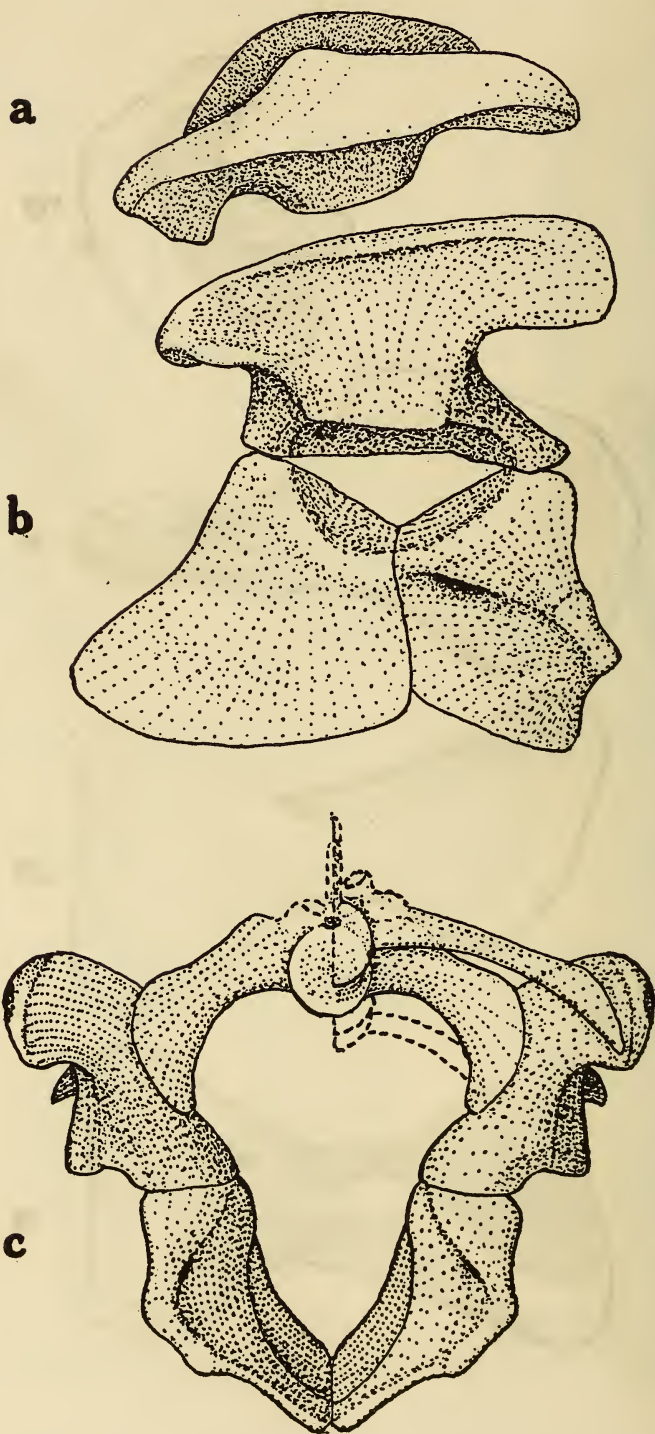
Fibula of *Struthiocephalus whaitsi*. S.A.M. 3012. ($\times \frac{1}{4}$.) a. Dorsal view. b. Ventral view. c. Anterior view.

Fig. 23.



Humerus of a juvenile *Struthiocephalus whaitsi*. S.A.M. 11493. ($\times \frac{1}{2}$.) a. Ventral view, b. Dorsal view, c. Anterior view, d. Proximal view.

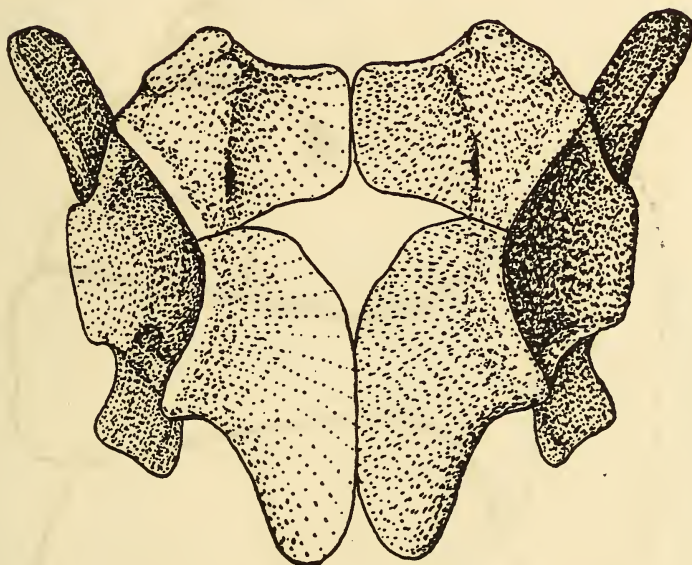
Fig. 24.



Struthiocephalus whaitsi. Juvenile. S.A.M. 11493. ($\times \frac{1}{4}$)
a. Ilium in dorsal view. b. Pelvis in lateral view. c. Pelvis
in anterior view.

S.A.M. 11939. A weathered humerus, ulna (Fig. 27 a-b) and femur (Fig. 27 d-f), associated with a jaw fragment. Dikbome, Laingsburg. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 25.



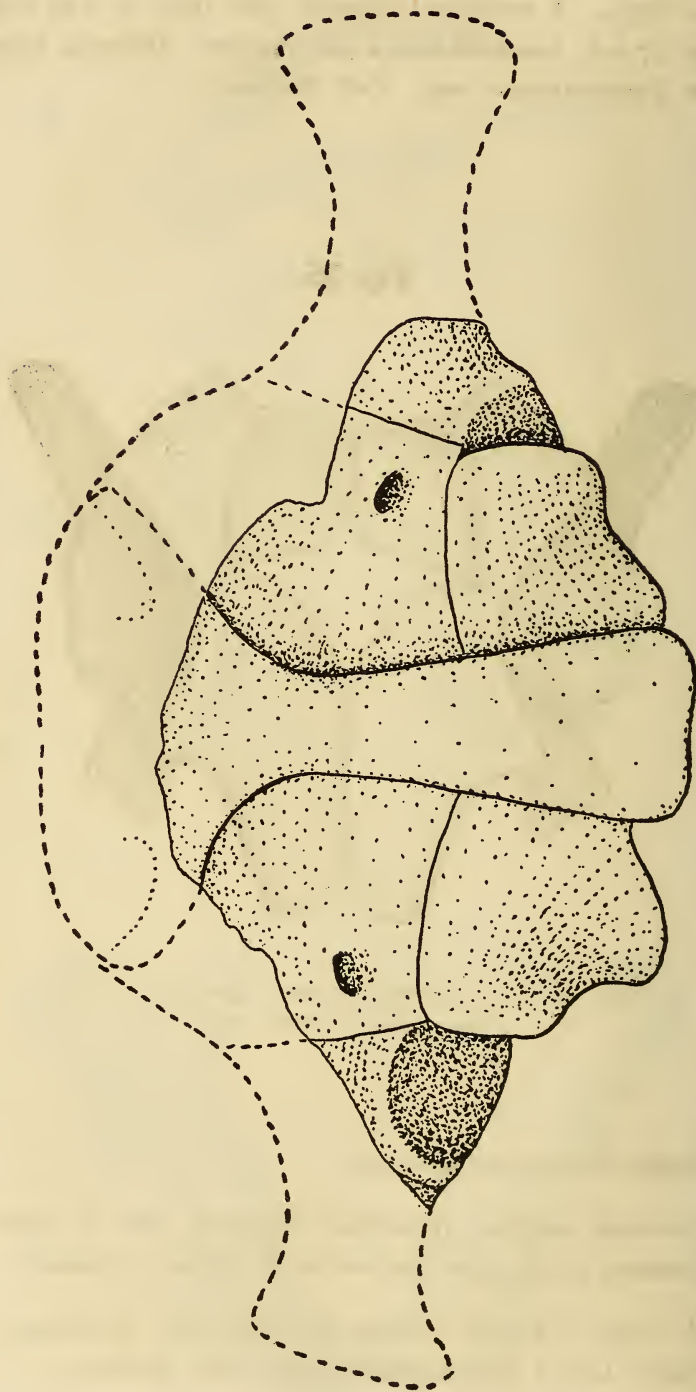
Pelvis of *Struthiocephalus whaitsi*. Juvenile. S.A.M.
11493. ($\times \frac{1}{6}$.) Ventral view.

Specifically undetermined specimen:

The following specimen approaches sufficiently close to warrant provisional inclusion in the genus, but not in the species — *whaitsi*.

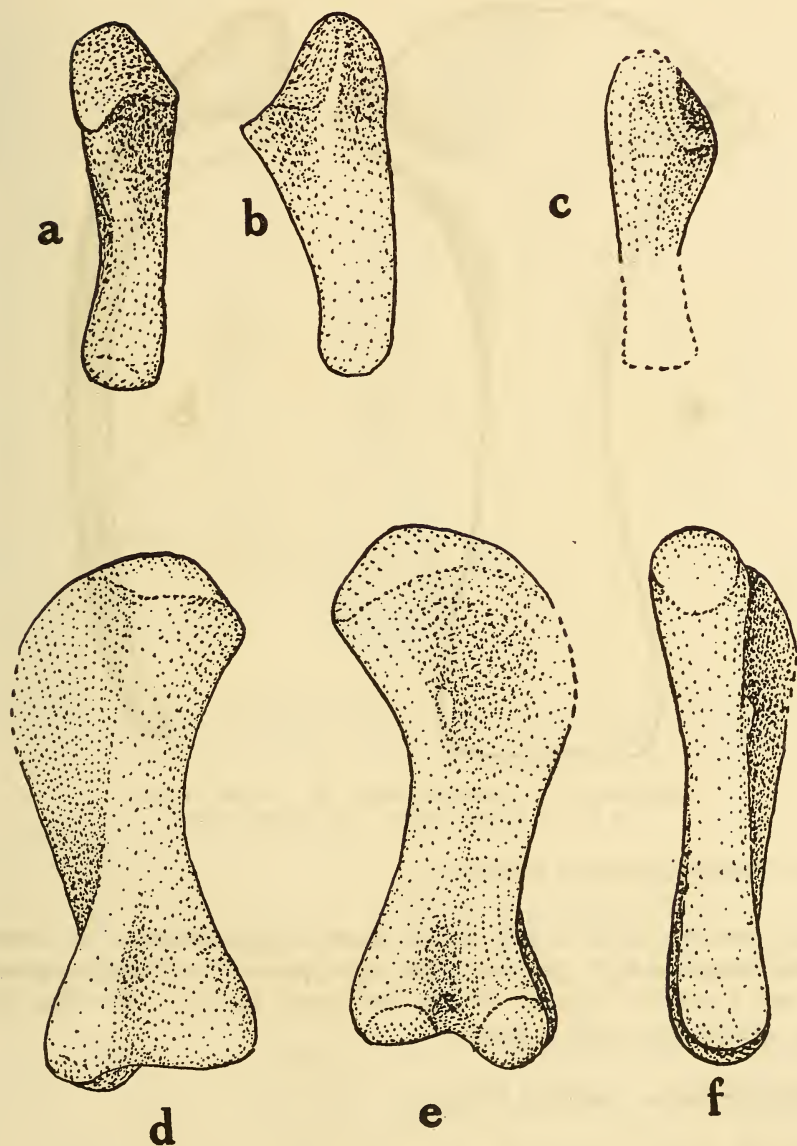
S.A.M. 11941. A good interclavicle (Fig. 28). Droëfontein, Prince Albert. Low ? *Tapinocephalus* zone. Coll. Boonstra.

Fig. 26.



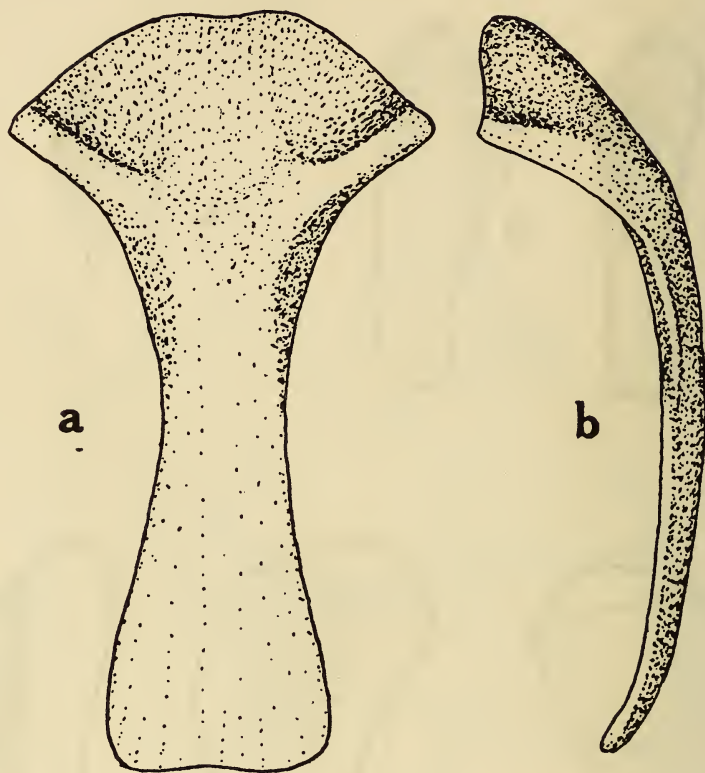
Pectoral girdle of *Struthiocephalus whaitisi*. S.A.M. 11572. ($\times \frac{1}{2}$.) Ventral view.

Fig. 27.



- a. Ulna of *Struthiocephalus whaitsi*. S.A.M. 11939. Dorsal view. ($\times \frac{1}{6}$)
 b. Ulna of *Struthiocephalus whaitsi*. S.A.M. 11939. Anterior view. ($\times \frac{1}{6}$)
 c. Ulna of *Struthiocephalus parvus*. S.A.M. 5006. Dorsal view. ($\times \frac{1}{6}$)
 d. Femur of *Struthiocephalus whaitsi*. S.A.M. 11939. Dorsal view. ($\times \frac{1}{6}$)
 e. Femur of *Struthiocephalus whaitsi*. S.A.M. 11939. Ventral view. ($\times \frac{1}{6}$)
 f. Femur of *Struthiocephalus whaitsi*. S.A.M. 11939. Anterior view. ($\times \frac{1}{6}$)

Fig. 28.



Interclavicle of *Struthiocephalus* sp. S.A.M. 11941.
($\times \frac{1}{8}$.) a. Ventral view. b. Lateral view.

Genus *Struthiocephaloides* Boonstra

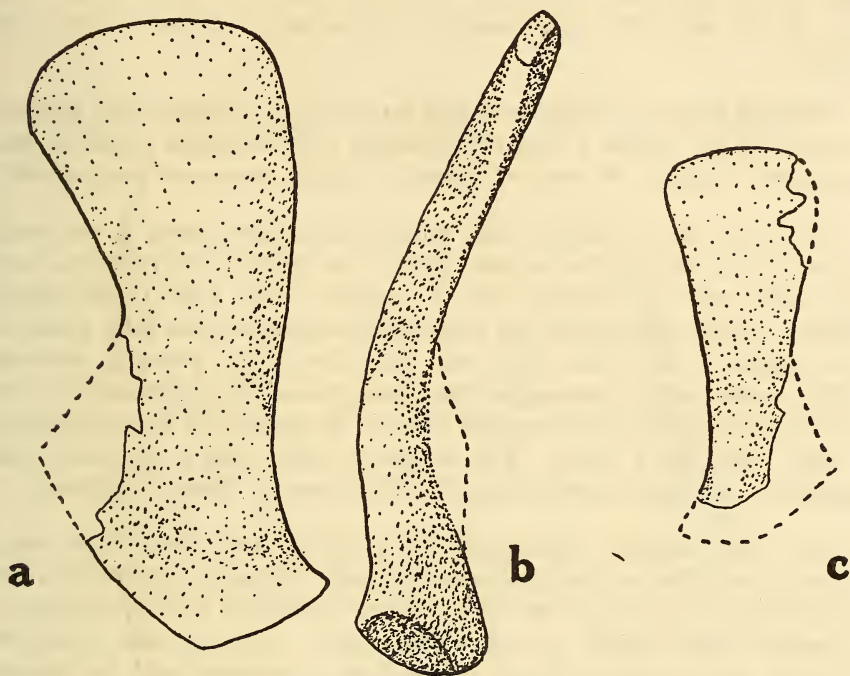
The pectoral girdle is only known from a single scapula; the scapula is fairly large and high (500 mm.); the upper part of the blade is expanded (210 mm.) and the posterior face is not deeply concave. No other part of the girdles and limbs is known.

Struthiocephaloides cavifrons Boonstra

Specific description as for the genus.

Type: S.A.M. 5607. A left scapula (Fig. 29 a-b), associated with a good skull. Lammerkraal, Prince Albert. High *Tapinocephalus* zone. Coll. Haughton.

Fig. 29.



Scapulae. ($\times \frac{1}{2}$.) a. *Struthiocephaloides cavifrons*, S.A.M. 5607. Lateral view.
 b. *Struthiocephaloides cavifrons*, S.A.M. 5607. Posterior view. c. *Struthiocephalellus parvus*, S.A.M. 5006. Lateral view.

Genus *Struthiocephalellus* Boonstra

The pectoral girdle is only known from an imperfect scapula and fragments of the coracoidal plate; the scapula is small (height 310? mm.) and the width of the blade is 210? mm.; the posterior face of the scapula is only slightly concave.

The humerus is small (length 276? mm.) and is lightly built; the proximal expansion is fairly great (156 mm.); the distal expansion is relatively great (174 mm.); the shaft is fairly long and fairly wide (diams. 66 $\times$ 48 mm.); the delto-pectoral crest is only moderately long and is fairly weak and terminates well proximal of the plane in which the ventral opening of the entepicondylar foramen lies; the relations of caput, processus medialis and lateralis are unknown; the radial condyle is weak (thickness 48 mm.), distally situated and curving round on to the dorsal surface; the twist on the

shaft is moderate (20° ?); the L.M.L. is weak and the A.D.V.L. fairly strong; the entepicondyle is expanded as a thin sheet of bone and the foramen enters ventro-postaxially and leaves as a ventral slit well away from the edge of the bone; the ectepicondyle is expanded as a thin curved sheet of bone.

The ulna has only the proximal part preserved; it is lightly built; proximal to the coronoid process a sharp longitudinal ridge separates a groove from the sigmoid surface; the ventral surface is deeply excavated longitudinally.

The pelvis has a relatively long pubo-ischiadic plate (97% of the height of the pelvis); the supra-acetabular part of the ilium is low (126 mm.) and long (200? mm. as restored) and the height is thus 63% of the length; although neither the anterior nor posterior iliac processes are fully preserved both appear to have been long and fairly low. The pubis is anteriorly slightly everted with a prominent tuberculum pubis, clearly demarcated from the medially directed antero-ventral edge of the pubis; the pubic symphysis is fairly long but is weak. The ischium is long with a long but weak symphysis; the postero-dorsal edge of the ischium is strongly thickened.

The femur is small, slender and fairly lightly built (length 276 mm.); the width over the external trochanter is small (95 mm.); the preaxial face is only slightly concave and the caput, which is relatively weak (55×25 mm.), is directed much dorsally as well as preaxially — there is thus a twist on the shaft; the external trochanter is indistinctly developed and the internal trochanter not developed at all; the shaft is long and fairly narrow and thin (diams. 55×48 mm.); the tibial facets face ventro-distally with the postaxial one lying further distally; the femoro-tibialis ridge is moderately strong and the ilio-femoralis area of insertion very narrow.

The tibia has its proximal face divided into two distinct concave facets by a sharp and strong dorso-ventral ridge; a prominent cnemial protuberance is present, continued distally as a sharp cnemial ridge, with a deep groove lying postaxially of this ridge; all these features are well and sharply modelled.

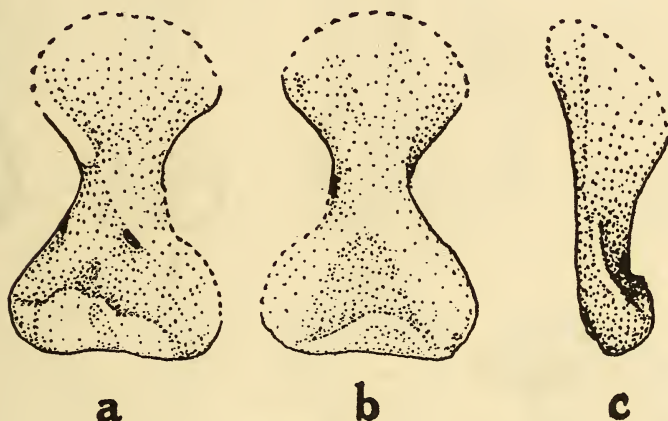
Struthiocephalellus parvus Boonstra

Type: S.A.M. 5006. A partial scapula (Fig. 29c), a fairly good humerus (Fig. 30), the proximal end of an ulna (Fig. 27c), a fairly good pelvis (Fig. 31), a good femur (Fig. 32) and the proximal end of a tibia (Fig. 33), associated with a fair skull. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

Generically undetermined specimens:

S.A.M. 8947. This specimen, which consists of two fairly good femora (Fig. 34 a-c), a good tibia (Fig. 34 d-f) and a good fibula (Fig. 34 g-i), appears to be of a *Struthiocephalid*, larger and of somewhat heavier build than *Struthiocephalus whaitsi*. The tibia is noteworthy for its very strong cnemial protuberance. Mynhardtskraal, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 30.



Humerus of *Struthiocephalellus parvus*. S.A.M. 5006.
($\times \frac{1}{2}$.) a. Ventral view. b. Dorsal view. c. Anterior view.

Fig. 31.



Pelvis of *Struthiocephalellus parvus*. S.A.M. 5006. ($\times \frac{1}{2}$.)
Lateral view.

The following four specimens are of *Struthiocephalids* which are much longer in the limb than *Struthiocephalus*.

S.A.M. 3614. A good isolated humerus (Fig. 35 b-e). This humerus is relatively long and slender (length 480 mm.); both the proximal (width 192 mm.) and the distal (width 198 mm.) expansion is small; the shaft is fairly long and slender (diams. 95×78 mm.); the twist on the shaft is small (8°); the capitellum is very weakly modelled and situated far distally; both epicondyles are weak and the entry of the entepicon-

dylar foramen is clearly visible in dorsal view. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

Fig. 32.

Right: Femur of *Struthiocephalellus parvus*. S.A.M. 5006. ($\times \frac{1}{8}$.) a. Dorsal view. b. Ventral view. c. Anterior view.

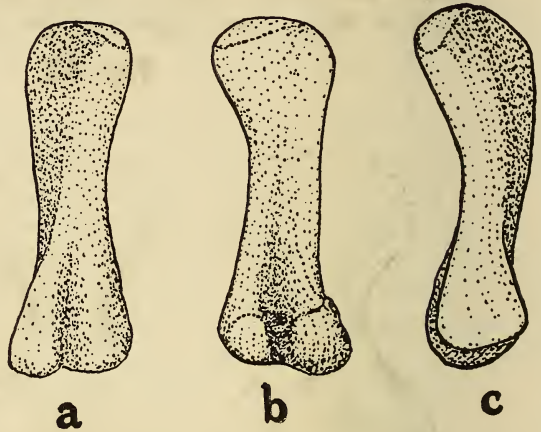
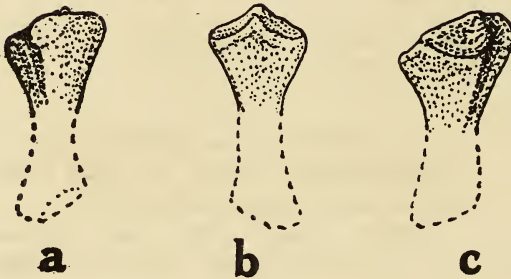


Fig. 33.

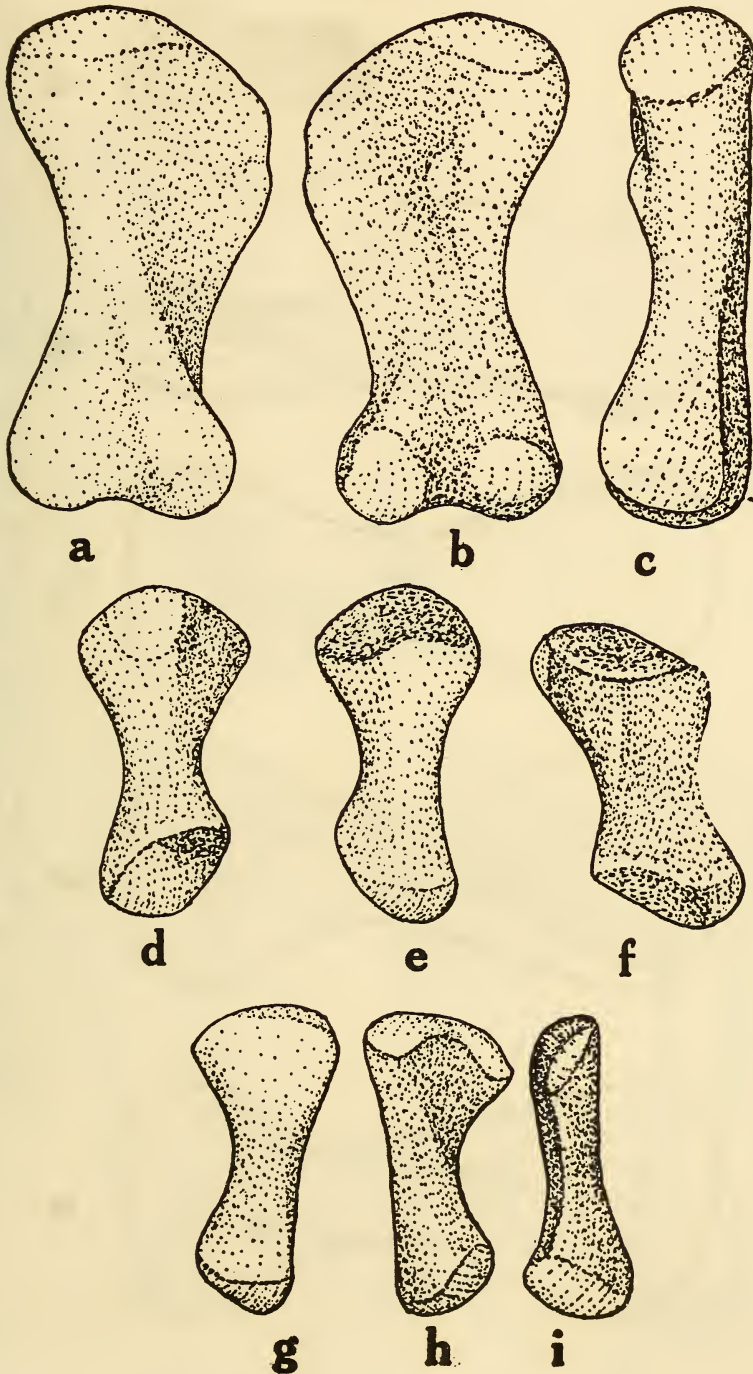


Left: Tibia of *Struthiocephalellus parvus*. S.A.M. 5006. ($\times \frac{1}{8}$.) a. Dorsal view. b. Ventral view. c. Posterior view.

S.A.M. 5009. A fair humerus with the proximal end not in contact with the shaft (Fig. 35a). Wolfefontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

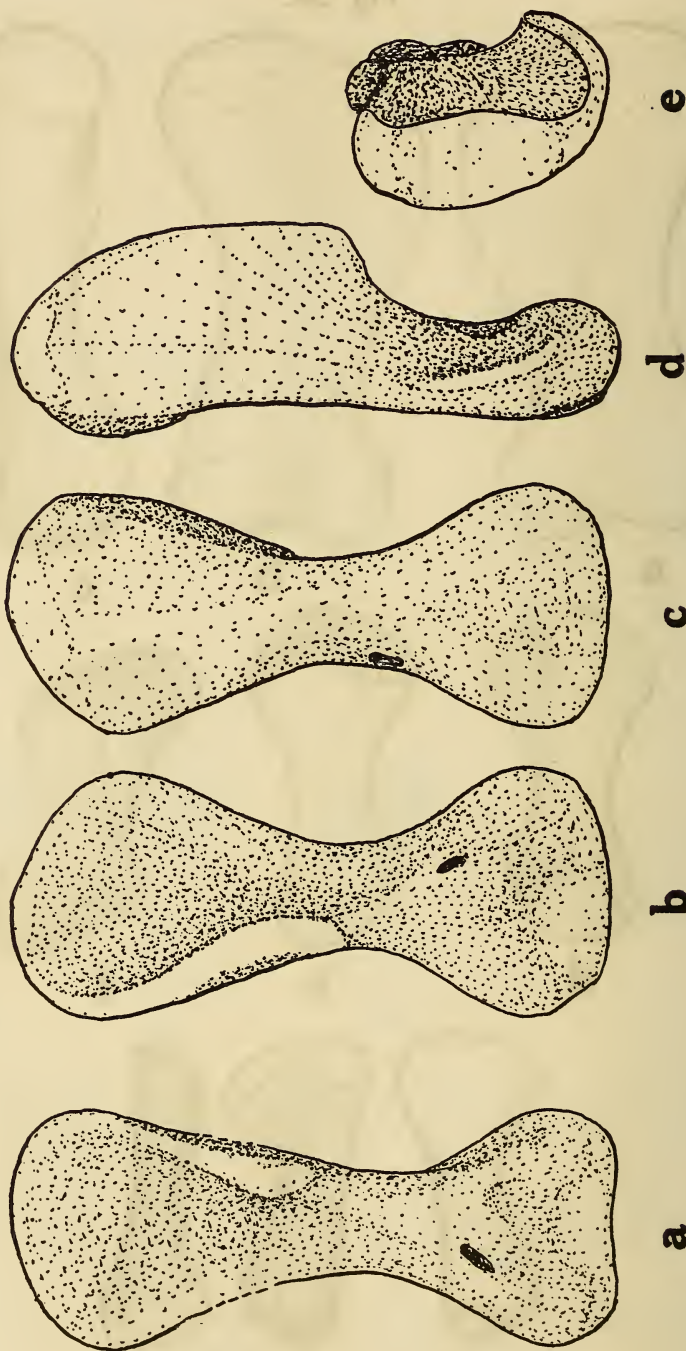
Although the delto-pectoral crest is shorter than in S.A.M. 3614 and the processus medialis situated more nearly in the same plane as the caput these two specimens probably are of the same species.

S.A.M. 4349. Two fairly good iliae (Fig. 36 a-b), a good femur (Fig. 36 c-e), the proximal halves of both ulnae (Fig. 36f) and of both tibiae and a fibula (Fig. 36g).

Fig. 34.

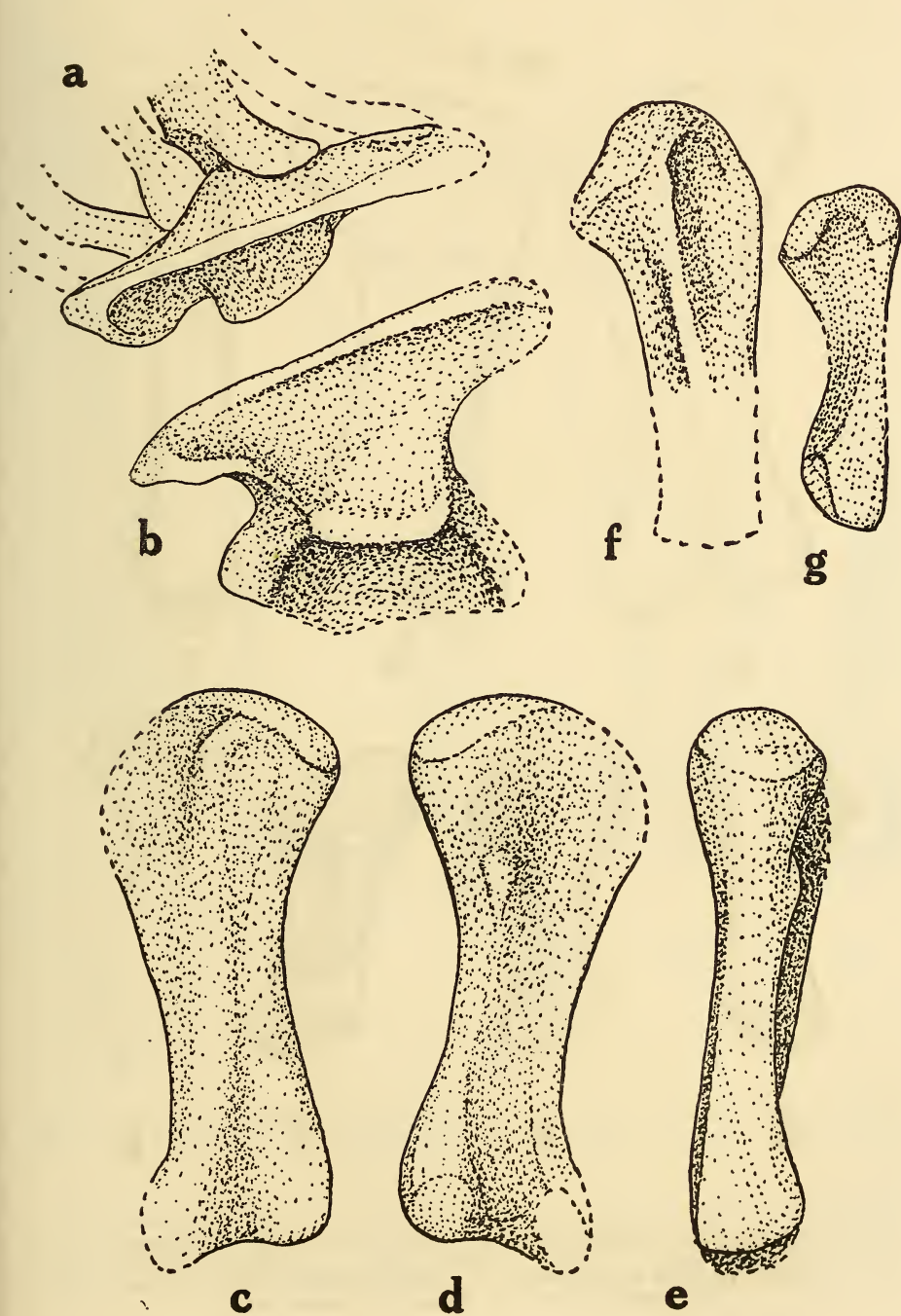
? *Struthiocephalus*. S.A.M. 8947. ($\times \frac{1}{4}$). a. Femur in dorsal view. b. Femur in ventral view. c. Femur in anterior view. d. Tibia in dorsal view. e. Tibia in ventral view. f. Tibia in posterior view. g. Fibula in dorsal view. h. Fibula in ventral view. i. Fibula in anterior view.

Fig. 35.



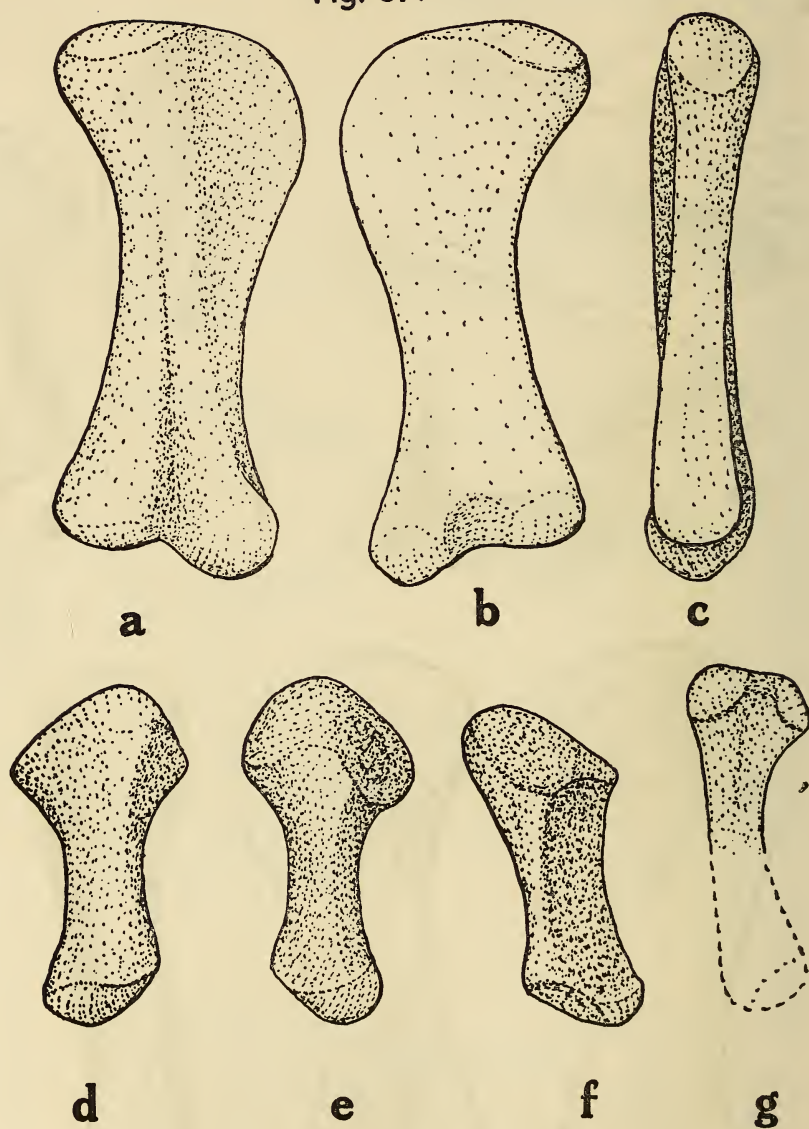
Humeri of an unnamed genus of the Struthiocephalidae. ($\times \frac{1}{4}$.) a. S.A.M. 5009. Ventral view. b. S.A.M. 3614. Ventral view. c. S.A.M. 3614. Dorsal view. d. S.A.M. 3614. Anterior view. e. S.A.M. 3614. Proximal view.

Fig. 36.



An unnamed *Struthiocephalid*. S.A.M. 4349. ($\times \frac{1}{6}$). a. Ilium in dorsal view. b. Ilium in lateral view. c. Femur in dorsal view. d. Femur in ventral view. e. Femur in anterior view. f. Ulna in dorsal view. g. Fibula in ventral view.

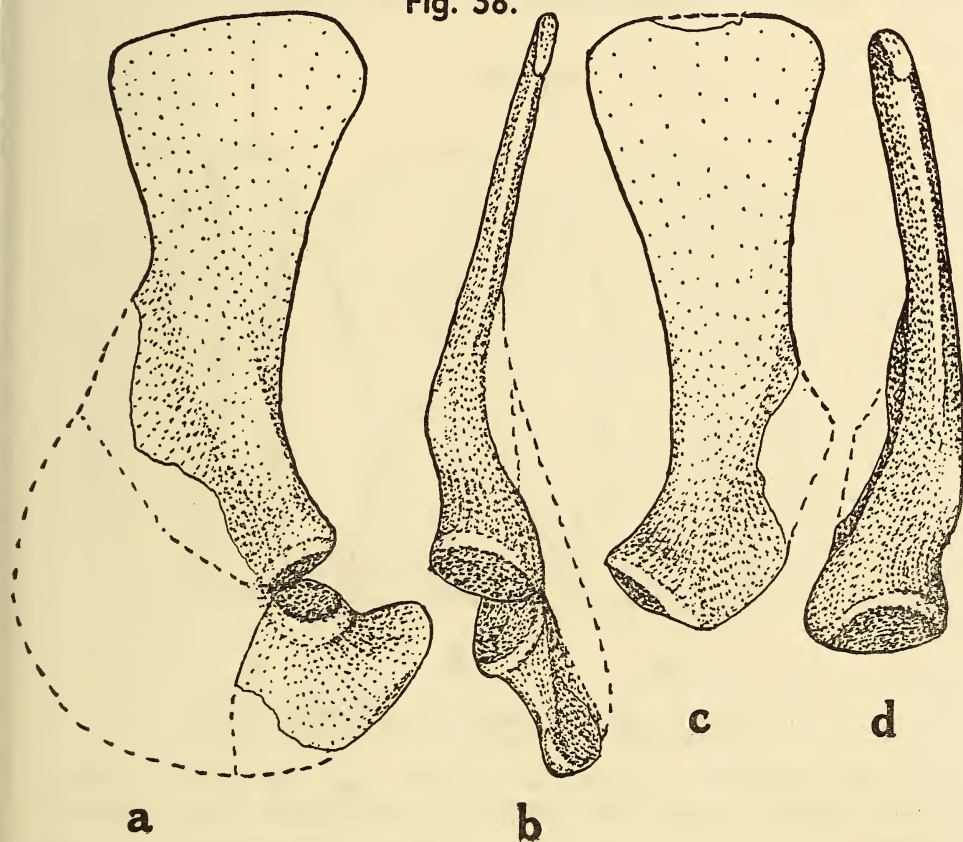
Fig. 37.



An unnamed Struthiocephalid. S.A.M. 9008 ($\times \frac{1}{2}$.) a. Femur in dorsal view. b. Femur in ventral view. c. Femur in anterior view. d. Tibia in dorsal view. e. Tibia in ventral view. f. Tibia in posterior view. g. Fibula in ventral view.

The ilium is low (supra-acetabular height 210 mm.), with both the anterior and the posterior process long and low (antero-posterior length 335? mm.); with the height thus 62% of the length; the anterior process is slightly everted and on its inner face receives a rib lying anterior to the main sacral rib; the origin of the m. ilio-fibularis lies on the everted horizontal ridge on the posterior iliac process; the dorsal edge of the ilium is folded over the upper limit of the gluteal area. It is thus apparent that this ilium is very similar to that of *Struthiocephalus*.

Fig. 38.



Scapulae of two indetermined *Struthiocephalids*. ($\times \frac{1}{8}$.) a. S.A.M. 10197. Lateral view. b. S.A.M. 10197. Posterior view. c. S.A.M. 11700. Lateral view. d. S.A.M. 11700. Posterior view.

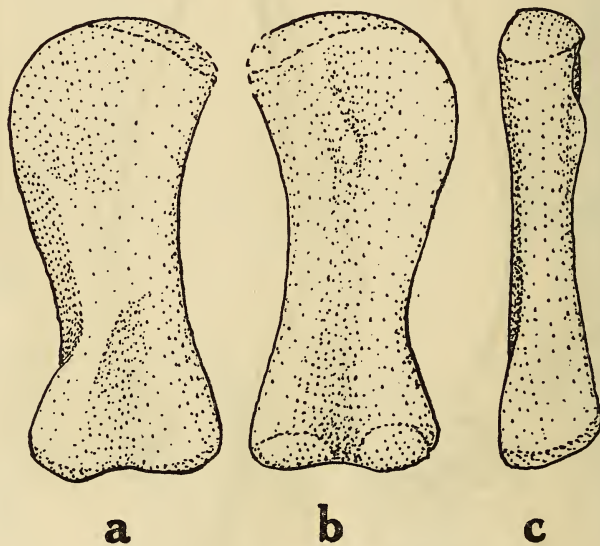
The femur is long (468 mm.) and slender; the width over the external trochanter apparently small (190? mm.); the preaxial face is quite strongly concave and the caput directed well preaxially; the internal trochanter is

situated fairly near the preaxial border; the shaft is long and narrow (diams. 102×66 mm.); the tibial facets are directed well distally with the postaxial one situated furthest distally.

The ulna is apparently long with a strong longitudinal ridge and a deep excavation on its dorsal face. The tibia and fibula are both long and slender bones.

Leeurivier, Beaufort West. Low *Tapinocephalus* zone. Coll. Haughton. S.A.M. 9008. A good femur (Fig. 37 a-c) and tibia (Fig. 37 d-f) and the proximal end of a fibula (Fig. 37g). Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 39.



Femur of uncertain affinity. S.A.M. 11880. ($\times \frac{1}{8}$.)
a. Dorsal view. b. Ventral view. c. Anterior view.

This specimen is co-specific with S.A.M. 4349. These two specimens thus represent, together with S.A.M. 3614 and S.A.M. 5009, a *Struthiocephalus* with an ilium very similar to that of *Struthiocephalus* but with much longer pro- and epipodials.

The following two specimens both come from the Nieuveveld, where the fauna of the *Tapinocephalus* zone is very poorly known.

S.A.M. 10197. An isolated well-preserved scapula and coracoid (Fig. 38 a-b). Grootfontein, Fraserburg. Low? *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11700. A good isolated scapula (Fig. 38 c-d). Elandsberg, Sutherland. Low? *Tapinocephalus* zone. Coll. Boonstra.

These two scapulae are clearly *Struthiocephalid* and they may yet prove to be of one or other of the forms as yet only known from skulls (e.g. *Struthionops*, *Riebeeckosaurus* or the other species of *Struthiocephalus*).

S.A.M. 11880. An isolated femur (Fig. 39). The affinities of this bone are very doubtful; the tibial condyles are practically terminal and the internal trochanter situated well away from the preaxial border. Arthurskraal, Beaufort West. High? *Tapinocephalus* zone. Coll. Geol. Survey.

Moschopidae

Family Characters of the Girdles and Limbs.

The girdles and limbs of the *Moschopidae* are only moderately well represented in our collection. There are a good number of pectoral elements of *Moschops*, but of the pelvic girdle there is only a single ilium, and the pro- and epipodials reasonably represented. In drawing up the descriptions I have drawn upon the accounts of Broom (11), Romer (25) and Gregory (18) of the *Moschops* material in the American Museum.

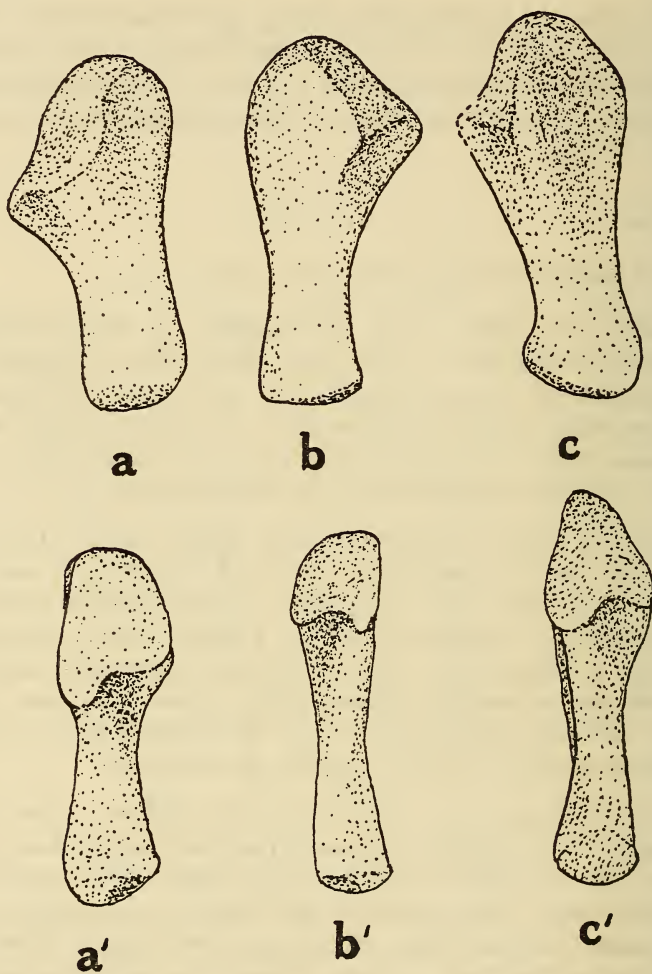
The pectoral girdle is lightly to fairly lightly built. The scapula is fairly low (400 mm.) to fairly high (440 mm.) or high (540 mm.) with the upper part of the blade broad (215 mm.) to fairly narrow (156-190 mm.); the posterior border is fairly straight; the tricipital ridge is moundlike, low and not very prominent; the canal for the supracoracoideus does not open directly into the subscapular groove, which, however, crosses the suture to meet the internal opening of the canal; the glenoidal facet of the scapula faces ventro-posteriorly, but not externally in *Avenantia*.

The coracoidal plate is not very long antero-posteriorly. The precoracoid is fairly large, but is mainly composed of a thin plate of bone which has its anterior edge only slightly thickened and its outer face moderately convex; the supra-coracoidal canal penetrates the bone very obliquely, so that its internal opening lies just below the precoracoid-scapular suture, with its upper rim notched and with a groove running into the subscapular groove; but in *Avenantia* the canal crosses the suture to open into the subscapular groove. The postero-dorsal apex of the precoracoid sometimes only just enters the anterior corner of the glenoid and here forms a slight depression in the ridge bounding the lateral edge of the glenoid.

The coracoid is small and light, but with a well-developed glenoidal facet, which faces postero-dorsally, but also well externally.

No cleithrum is preserved in any of my specimens, but if present could only have been a splintlike bone as found by Broom (II) in one of the Spitskop specimens.

Fig. 40.



Moschopid ulnae. ($\times \frac{1}{6}$.) a, a'. ? *Moschops*. S.A.M. 9124A in dorsal and anterior views. b, b'. ? *Moschops*. S.A.M. 9157, in dorsal and anterior views. c, c'. *Moschops capensis*. S.A.M. 11292, in dorsal and anterior views.

Of the clavicle only one dorsal and two ventral ends are preserved. Dorsally the posterior expansion overlying the scapula is relatively better developed than in *Struthiocephalus* and the *Titanosuchia*.

The interclavicle is a fairly large and strong bone, with a relatively long stem expanded posteriorly; anteriorly the spatulate end is not greatly expanded and the articulatory surface for the reception of the lower end of the clavicle is only slightly excavated, with the development of a slight groove in only one specimen. In my material the anterior end is not bent up as sharply as in the Spitskop material. There is no median ridge on the dorsal surface of the stem as in some *Titanosuchia*.

The humerus is moderately long (345-444 mm.); the proximal expansion is moderate to fairly large (170-240 mm.); the distal expansion is moderate (165?-240 mm.); the shaft is fairly long and moderately broad (width 78-91 mm.); the delto-pectoral crest is fairly short and its distal end lies well proximal of the ventral opening of the entepicondylar foramen; the caput is narrowly oval; both the processus medialis and the processus lateralis lie far proximally, more or less in the same plane as the caput; the radial condyle is fairly weak, not well modelled and it lies far distally and does not extend along the ventral face, and thus lies well distally of the entepicondylar foramen, but does curve a little round on to the dorsal face; the twist on the shaft is small to moderate (10-20°); the L.M.L. is moderately strong; the A.D.V.L. is distinct; the entepicondyle is moderately to fairly greatly expanded to form a thin curved sheet of bone, and the foramen is slitlike with its entrance visible in dorsal view on the dorso-postaxial border; the ectepicondyle is strongly expanded as a thin sheet of bone with ventrally, in some humeri, a well-marked groove functioning as does the ectepicondylar foramen in the Titanosuchids for the passage of the radial nerve.

The ulna is fairly light to moderate (length 275-300 mm.); the dorsal lip to the sigmoid face is weak to fairly strong; the styloid ridge is moderately strong.

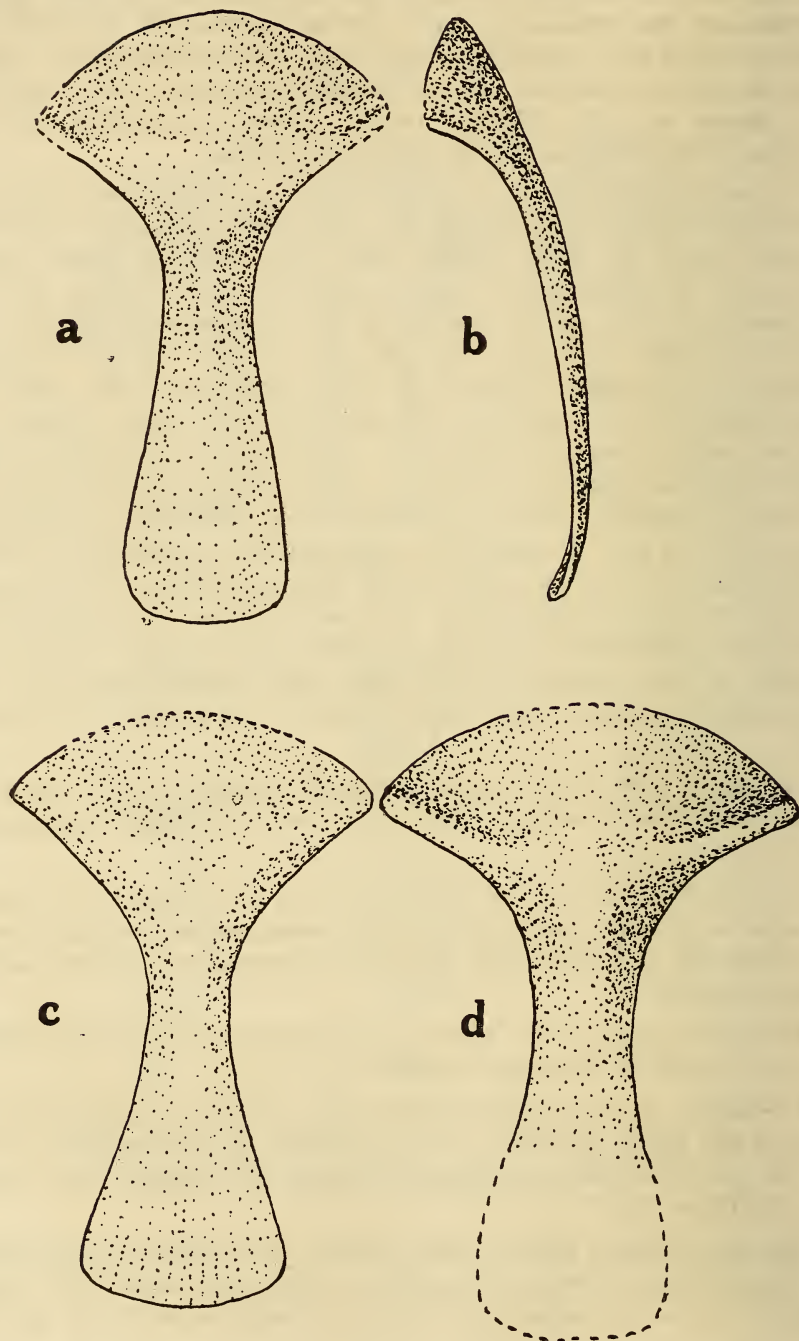
The radius is relatively long (186-204 mm.); it is a slender nearly featureless bone or is fairly robust, with a fairly strong proximo-postaxial flange; the ventral face is longitudinally moderately concave; the proximal facet is slightly convex.

The manus, fully known in only one specimen, has the carpal formula 3-4, 1-2, 5, and the phalangeal formula 2, 3, 3, 3, 3.

The pelvis. As our collection contains only a single incomplete Moschopid ilium of the genus *Avenantia*, I am extracting the characteristic features for this group from the descriptions by Broom (11), Romer (25), Gregory (18) and Byrne (16).

The pubo-ischiadic plate is short (70-80% of the height of the pelvis); the supra-acetabular part of the ilium is high and fairly short (height 73%-75% of its antero-posterior length); the anterior process of the iliac

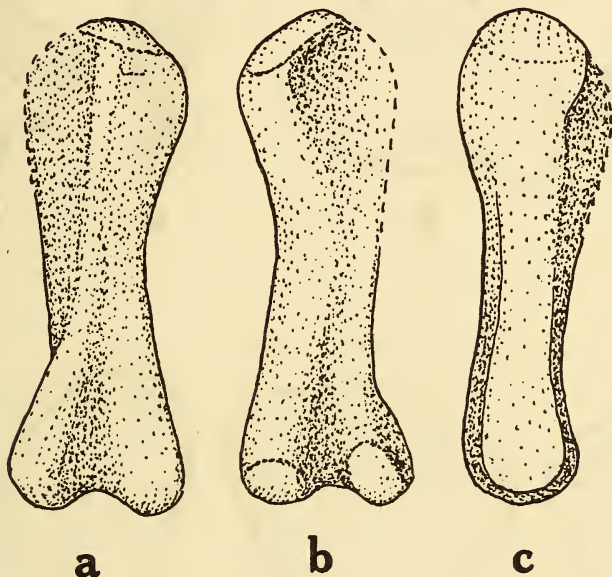
Fig. 41.



Interclaviculae of *Moschops capensis*. ($\times \frac{1}{2}$.) a. S.A.M. 11972, in ventral view. b. S.A.M. 11972, in lateral view. c. S.A.M. 11972a, in ventral view. d. S.A.M. 11975, in ventral view.

blade is fairly long and high and diverges fairly strongly laterally; the posterior process is somewhat shorter and appreciably to greatly lower than the anterior process, and its ventro-posterior edge lies fairly horizontally and this is slightly everted, but without forming a definite ridge for the ilio-fibularis; the dorsal iliac edge is slightly folded over laterally; there is apparently no face for the attachment of a rib lying anteriorly of the main sacral rib on the inner face of the anterior iliac process.

Fig. 42.

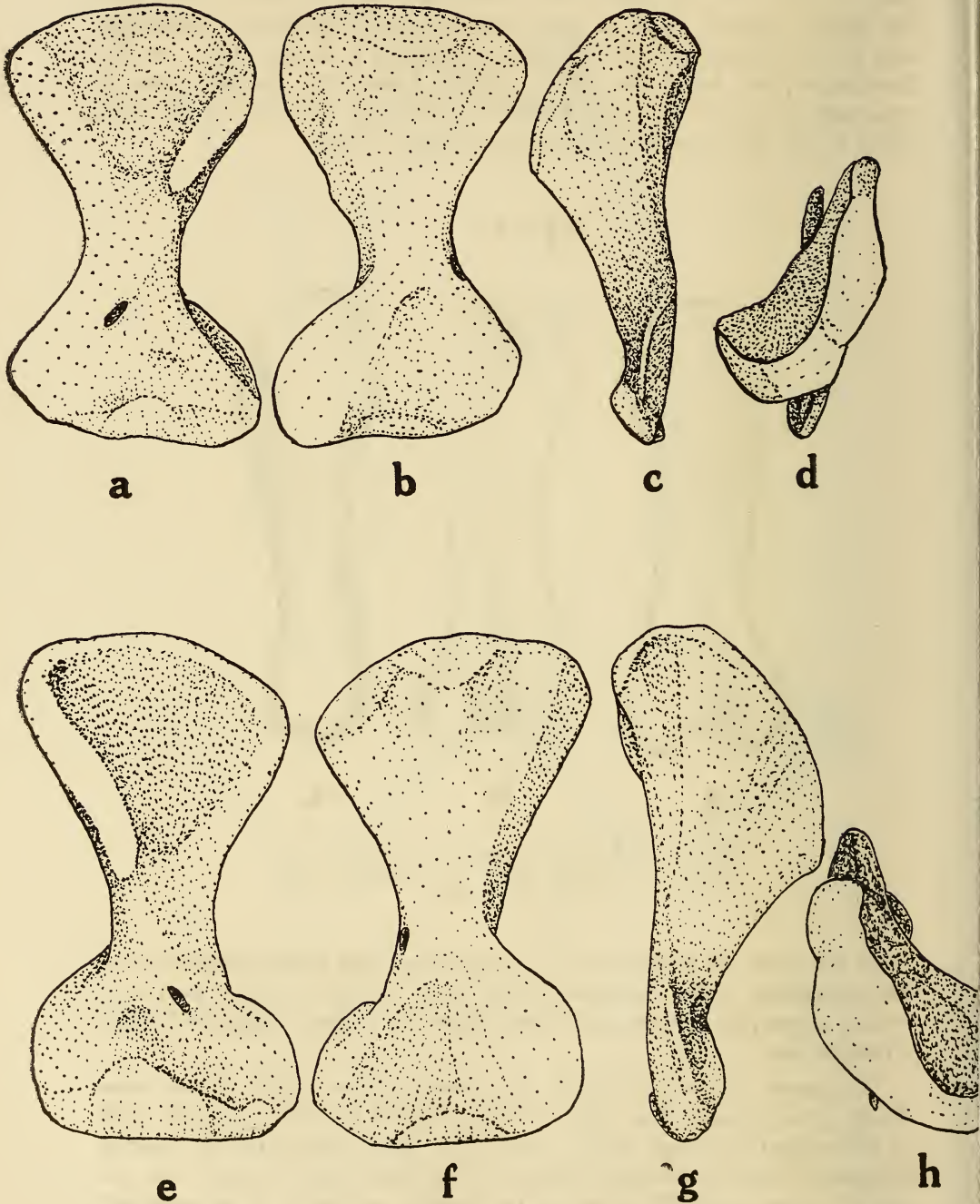


Femur of *Moschops capensis*. S.A.M. 11974.
($\times \frac{1}{4}$) a. Dorsal view. b. Ventral view.
c. Anterior view.

In the pubis the anterior edge is everted and ends antero-externally in a low tuberculum pubis; the pubes barely meet in their posterior part in a median symphysis; the two ischia meet below in a deep symphysis forming a median keel.

The femur of the Moschopids is a medium-sized, fairly robust bone (length 310-414 mm.); the width over the external trochanter is fairly small to fairly great (120?-205 mm.); there is no notch separating the external trochanter from the proximal surface; the preaxial face is deeply concave and the caput preaxially directed; the internal trochanter is undeveloped;

Fig. 43.



Humeri of *Moscopus capensis*. ($\times \frac{1}{2}$.) a. S.A.M. 11976. Ventral view. b. S.A.M. 11976. Dorsal view. c. S.A.M. 11976. Anterior view. d. S.A.M. 11976. Proximal view. e. S.A.M. 11975. Ventral view. f. S.A.M. 11975. Dorsal view. g. S.A.M. 11975. Anterior view. h. S.A.M. 11975. Proximal view.

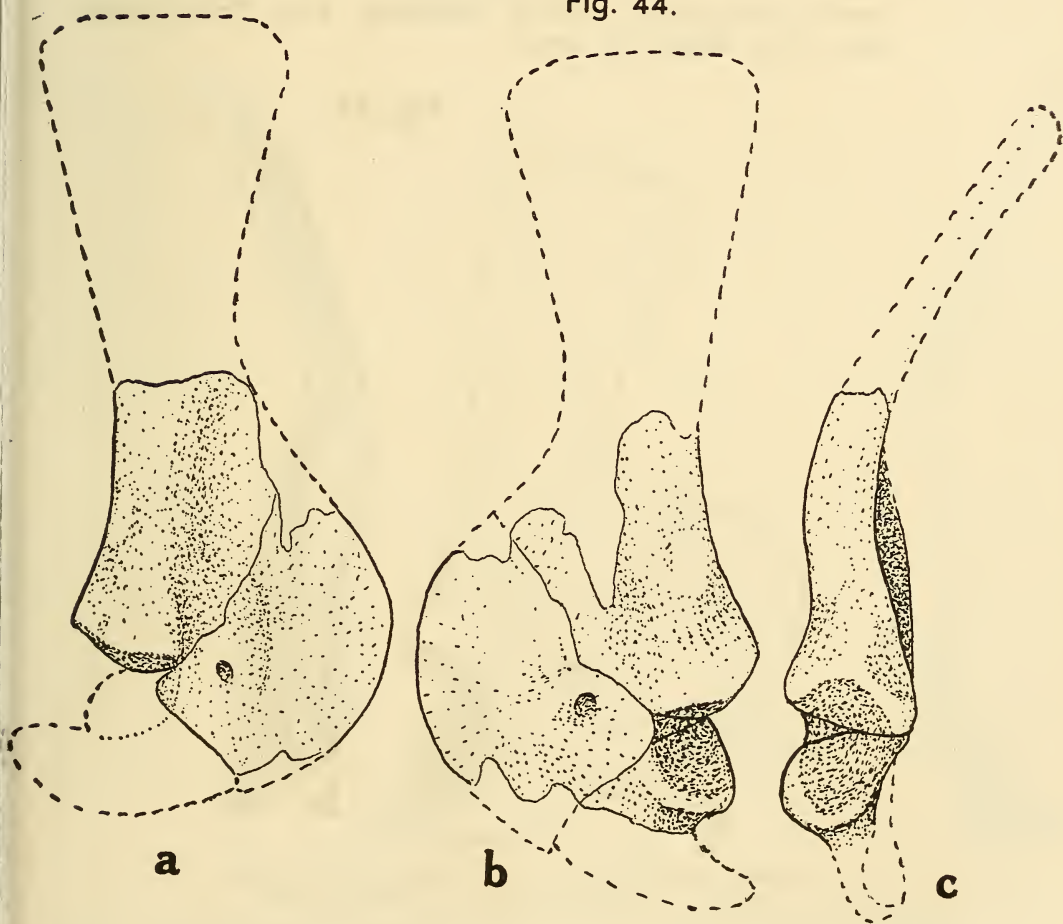
the shaft is fairly long, fairly to moderately broad (84-110 mm.); the condyles are much distally directed, with the external condyle situated slightly or considerably further distally than the internal condyle; the ilio-tibialis ridge is fairly strong and the area for the insertion of the ilio-femoralis quite broad.

The tibia is medium-sized (length 210-270 mm.); cnemial ridge and groove fairly well developed.

The fibula is lightly built, slender and relatively long (222-258 mm.).

The pes is only fully known in one species; here the tarsal formula is 2, 1, 4 and the phalangeal formula 2, 3, 3, 3, 3.

Fig. 44.



Scapulo-coracoids of *Moschops capensis*. ($\times \frac{1}{6}$.) a. S.A.M. 11976a. Lateral view. b. S.A.M. 11976b. Lateral view. c. S.A.M. 11976b. Posterior view.

Genus *Moschops* Broom

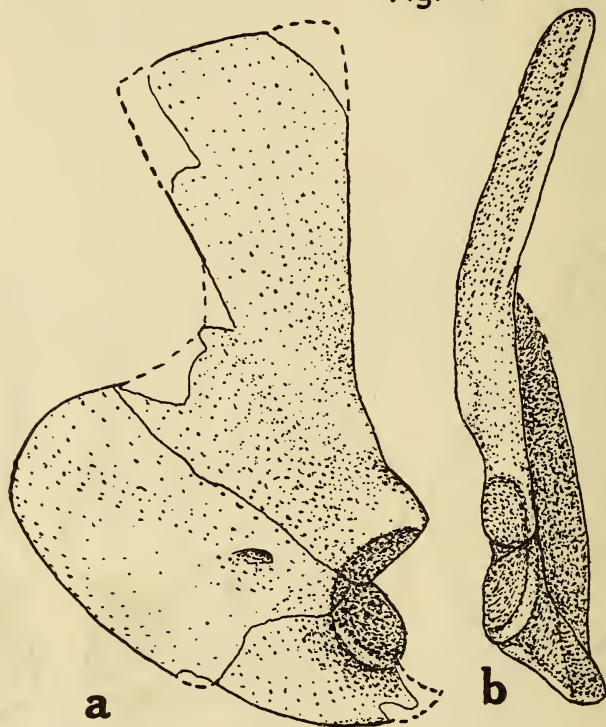
The pectoral girdle is lightly built; the scapula is fairly high (440-515 mm.) with the upper part of the blade fairly narrow (174-190 mm.); the glenoidal facet of the scapula faces externally as well as ventro-posteriorly. The femur is a medium-sized fairly robust bone (length 310-390 mm.). For other characters see the family description.

Moschops capensis Broom

The specific description is as for the genus.

Topotypes: A.M.N.H. 5551-5557. Remains of seven or eight skeletons, associated with skulls. Spitskop, Laingsburg. Low? *Tapinocephalus* zone. Coll. Whaits and Broom.

Fig. 45.



Scapulo-coracoid of *Moschops capensis*. ($\times \frac{1}{2}$). S.A.M. 11976e. a. Lateral view. b. Posterior view.

Referred specimens in the S.A.M. collection:

S.A.M. 11292. An ulna (Fig. 40c), associated with a skull 11291.

S.A.M. 11971. A distorted humerus, associated with a distorted skull.

S.A.M. 11972. Two interclaviculae (Fig. 41 a-c) and two distal and one proximal end of the clavicle (Fig. 17e), found near a skull, 11972.

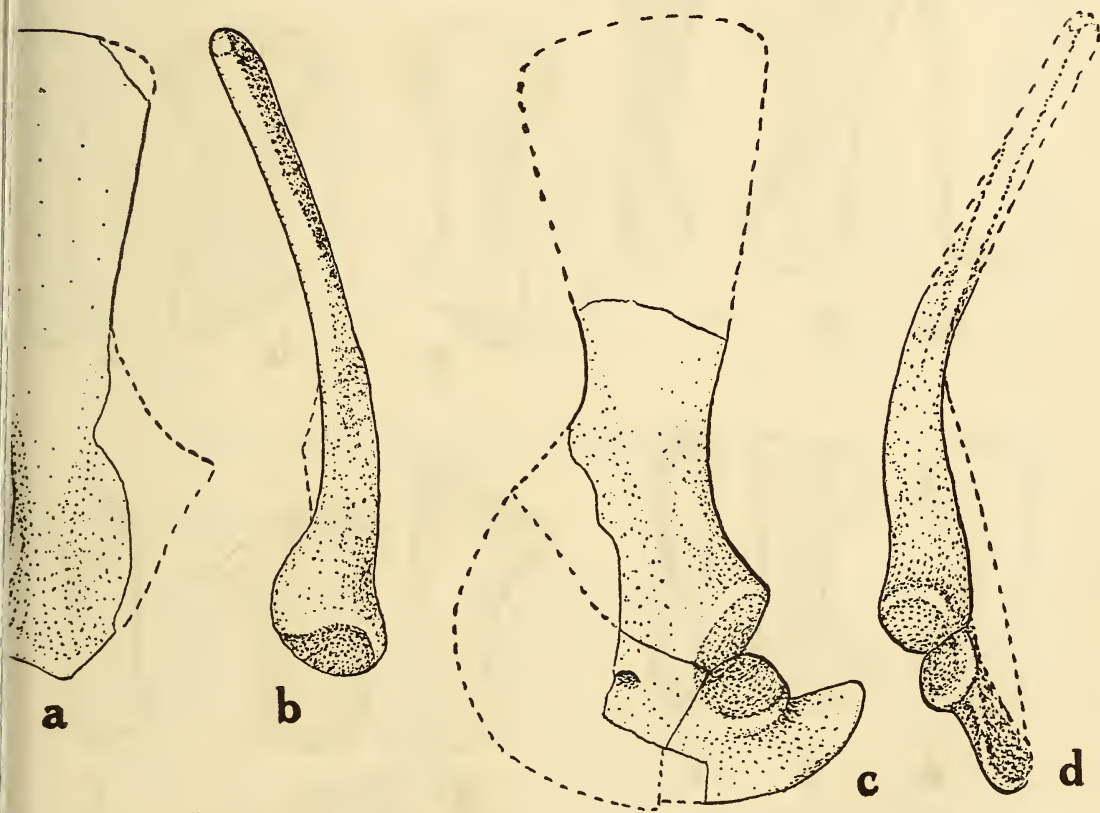
S.A.M. 11974. A femur (Fig. 42), associated with a skull.

S.A.M. 11975. Part of a scapula, a humerus (Fig. 43 e-h) and an incomplete interclavicula (Fig. 41d).

S.A.M. 11976. A good humerus (Fig. 43 a-d).

S.A.M. 11976 a, b, c, d and e. Five coraco-scapulae (Figs. 44 and 45).

Fig. 46.

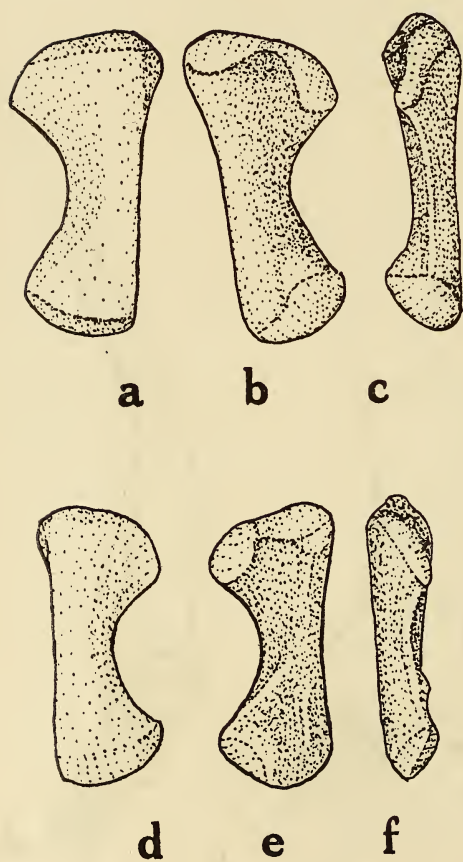


Scapula of *Moschops capensis*. S.A.M. 11977a. ($\times \frac{1}{2}$.) a. Lateral view. b. Posterior view. Coraco-scapula of *Moschops capensis*. S.A.M. 11977b. ($\times \frac{1}{2}$.) c. Lateral view. d. Posterior view.

S.A.M. 11977 a-d. A scapula (Fig. 46a, b) and an incomplete coraco-scapula (Fig. 46c, d), two fibulae (Fig. 47) and three tibiae (Fig. 48), together with a number of incomplete and weathered girdle and limb-bones.

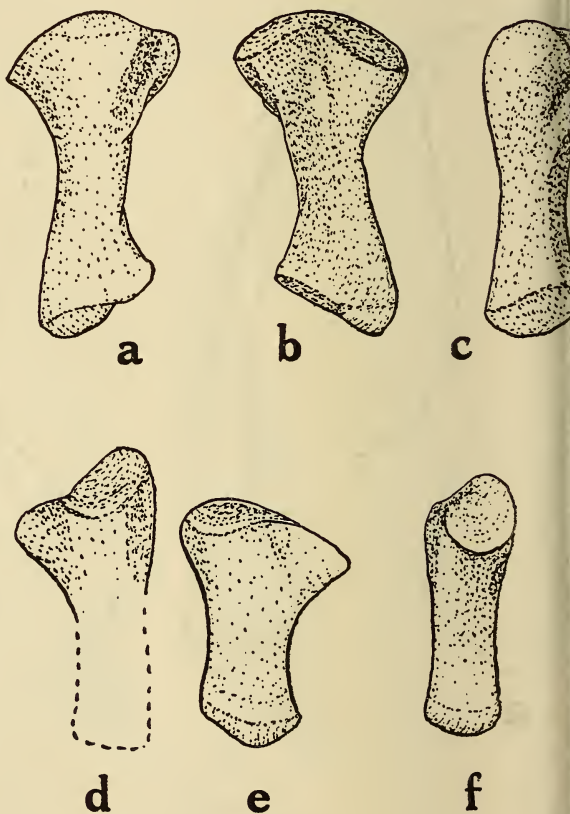
S.A.M. 11978. An isolated coracoid.

Fig. 47.



Fibulae of *Moschops capensis*. ($\times \frac{1}{2}$)
a. S.A.M. 11977c. Dorsal view.
b. S.A.M. 11977c. Ventral view.
c. S.A.M. 11977c. Anterior view.
d. S.A.M. 11977d. Dorsal view.
e. S.A.M. 11977d. Ventral view.
f. S.A.M. 11977d. Anterior view.

Fig. 48.

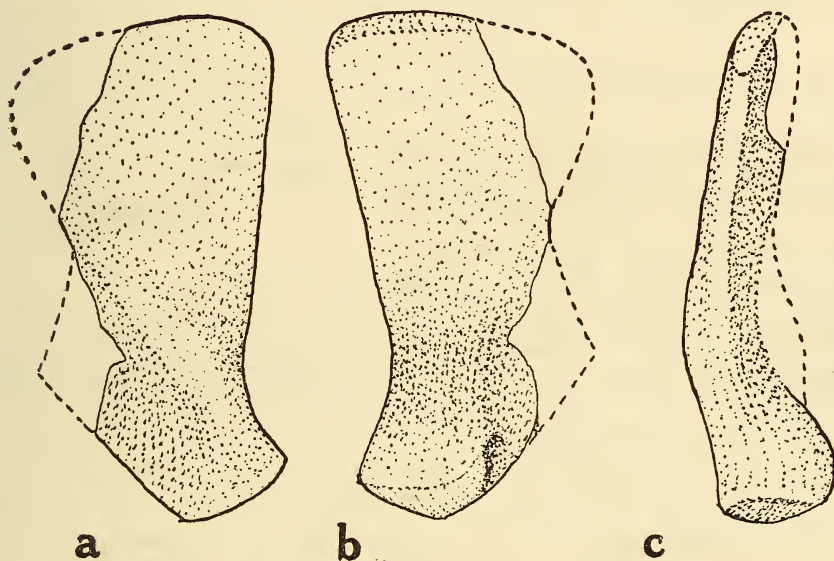


Tibiae of *Moschops capensis*. S.A.M. 11977. ($\times \frac{1}{2}$)
a. Normal left tibia in dorsal view. b. Normal left tibia in ventral view. c. Normal left tibia in posterior view. d. Deformed left tibia in dorsal view. e. Crushed right tibia in dorsal view. f. Crushed right tibia in posterior view.

All the above specimens were found in an area of about 500 sq. yards, associated with the remains of at least twenty *Moschops* skulls, mostly badly weathered.

Kruisvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 49.



Scapula of *Avenantia kruisvleiensis*. S.A.M. 9167. ($\times \frac{1}{6}$.) a. Lateral view. b. Internal view. c. Posterior view.

Genus *Avenantia* Boonstra

The girdles and limbs are very inadequately known. The scapula is low (400 mm.), and apparently with a very broad blade (width 210 mm.); the glenoidal facet faces ventro-posteriorly and not externally at all; the supracoracoid canal crosses the suture into the scapula to open into the subscapular groove. The ilium is incompletely preserved, but its blade is fairly low, and both the anterior and posterior processes are long and low.

On the other hand the femur is very *Moschops*-like; it is a moderately robust bone with a length of 378 mm.; 168 mm. wide over the external trochanter; the preaxial face is deeply concave and the caput directed well preaxially; the shaft is fairly slender (diams. 96 $\times$ 60 mm.); the condyles face ventro-distally and the postaxial condyle is situated much further distally than the preaxial condyle.

Avenantia kruisvleiensis Boonstra

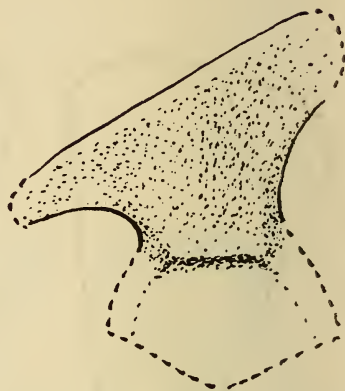
The specific description is as for the genus.

Type: S.A.M. 9167. A scapula, a weathered ilium (Fig. 50) and a good femur (Fig. 51), associated with a fairly good skull. Kruisvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Genus *Moschognathus* Broom

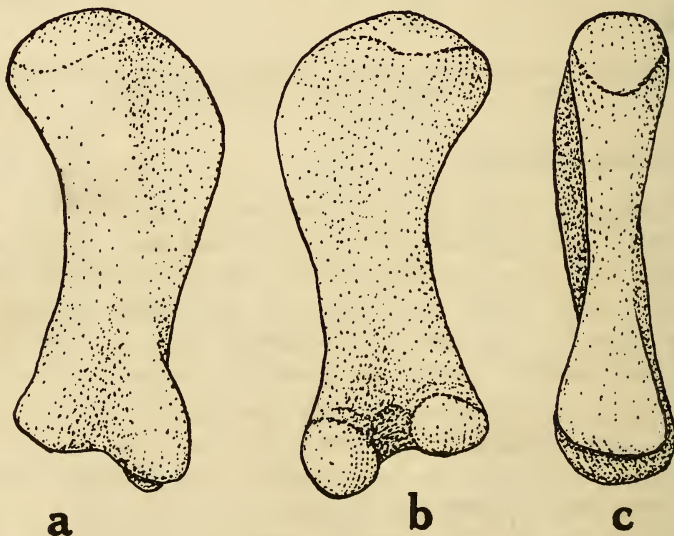
There is no specimen in the South African Museum referable to this genus and in the only known specimen only some features of the pelvis and femur are known. These point to a large measure of similarity with the corresponding bones in *Moschops* (see Gregory's (18) Plate).

Fig. 50.



Right ilium of *Avenantia kruisvleiensis*. S.A.M. 9167. ($\times \frac{1}{6}$)
Lateral view.

Fig. 51.



Femur of *Avenantia kruisvleiensis*. S.A.M. 9167. ($\times \frac{1}{6}$)
a. Dorsal view. b. Ventral view. c. Anterior view.

Moschognathus whaitsi Broom

Type: A.M.N.H. 5602. Part of the pelvis, two femora and partial vertebral column, associated with parts of a skull and lower jaw. Beaufort West District. ? *Tapinocephalus* zone. Coll. Whaits.

Genus *Pnigalion* Watson

In our collection there is no specimen that can be referred to *Pnigalion*. In the only known specimen in the British Museum, Watson (29) has associated with the skull a humerus, femora and a tibia. The humerus is medium sized and fairly robust (length 455? mm.) with a greatly expanded proximal end (width 246 mm.); the shaft is fairly long and broad (breadth 102 mm.); the strong delto-pectoral crest terminates well proximal of the entepicondylar foramen; the ectepicondyle apparently greatly expanded as a thin sheet of bone.

The femur figured by Watson is a stout and fairly squat bone (length 420 mm.); width over the external trochanter 216 mm. and the width of the shaft 144 mm.). Another femur, consisting of distal and proximal ends not in contact, represents a long fairly slender bone with a preaxially directed head. I took the following measurements in 1934: width across external trochanter 205 mm., across the epicondyles 170 mm. and the diameters of the shaft 110 × 70 mm. It would thus appear that Watson's figure is that of a dorso-ventrally crushed femur, which thus appears much broader than it was in life and in that case it would not be so very different from the *Moschops* femur.

Pnigalion oweni Watson

The specific description is as for the genus.

Type: B.M. R.3596 (and R.3606). A humerus, femora and tibia, considered to be associated with a partial skull. De Cypher, Beaufort West. Low? *Tapinocephalus* zone. Coll. unknown?

Genus *Moschoides* Byrne

As there is no specimen referable to this genus in this collection I am extracting the following from Byrne's description:

"The scapula is a massive bone, thickened greatly along its posterior edge. It forms the upper part of the glenoid cavity. The coracoid, which forms the remainder of the glenoid, is a rather small element, but bears a

well-developed coracoid process. The precoracoid is much larger, considerably thinner, and is moderately convex. It is thickened only in the glenoidal corner where, also, it is pierced by a large supra-coracoid foramen. The clavicles are moderately expanded elements somewhat constricted in their middle portions. The humerus is a powerfully developed element. There is a strong delto-pectoral crest, a somewhat constricted shaft, and two moderately developed distal condyles. Apparently there is only an entepicondylar foramen.

Both radius and ulna are conspicuously flattened antero-posteriorly. The ulna, the longer bone, carries a strong olecranon process.

The carpus consists of three rather large proximal elements, two central elements, and five rather small distal carpals. The metacarpals are unusually small with the exception of the fifth which is expanded and platelike. The phalangeal formula is 2, 3, 3, 3, 3; the first phalanx in each digit being unusually short.

The pelvic girdle is characterised particularly by the large anterior process of the ilium. The acetabulum is roughly circular in outline.

The femur is a long element and is considerably flattened antero-posteriorly. It bears a well-defined head and two sharply demarked distal condyles. The lesser trochanter is not evident but the great trochanter is well developed.

The tibia is very short. While greatly constricted along its shaft, it flares broadly at either end.

The tarsus is represented by a massive astragalus, an expanded platelike calcaneum, a rather small navicular, and four distal tarsals, the first three of which are quite small. It would seem that a good deal of cartilage must have been present in life to complete the ankle structure.

The metatarsals and the digits are similar in size and shape to the corresponding elements in the forefoot. The distal portion of the hindfoot is much weaker, however, in comparison with the forefoot."

Moschoides romeri Byrne

Specific description is as for the genus.

Type: Walker Museum. No. ? The pectoral girdle, humerus, radius, ulna and manus; a fair pelvic girdle, femur, tibia, part of the fibula and the pes. Hottentotsrivier, Beaufort West. High? *Tapinocephalus* zone. Coll. Romer and Miller.

Generically undetermined specimens:

S.A.M. 1057. An isolated good femur (Fig. 52).

Fig. 52.

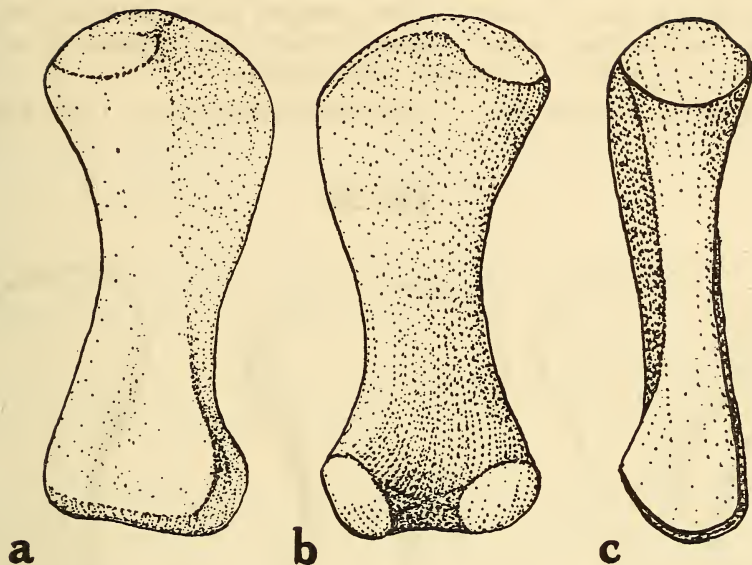
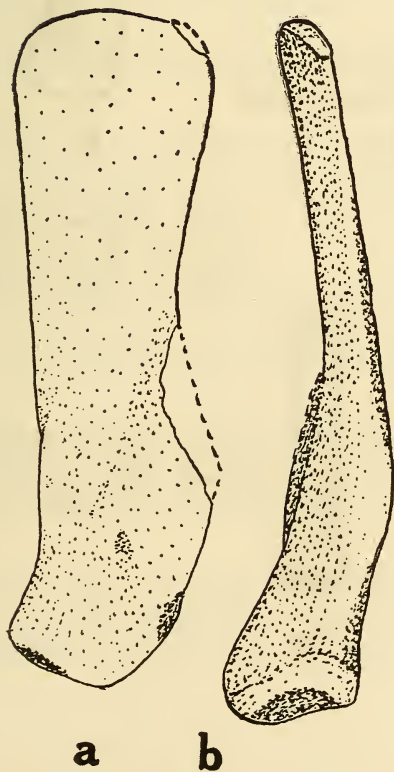


Fig. 53.

Above: Femur of a Moschopid intermediate between *Moschops* and *Pnigalion*. S.A.M. 1057. ($\times \frac{1}{8}$.)
 a. Dorsal view. b. Ventral view.
 c. Anterior view.



Left: Scapula of a Moschopid. Gen. Indet. S.A.M. 9003. ($\times \frac{1}{8}$.)
 a. Lateral view. b. Posterior view.

This is a medium sized (length 414 mm.) fairly robust bone (width over the external trochanter 180 mm.); the shaft is fairly long and moderately broad (diams. 102×72 mm.); both condyles lie in practically the same plane; the ilio-tibialis ridge is strong. This femur appears to lie about midway between that of *Moschops* and *Pnigalion*.

Letjiesbos, Beaufort West. Mid *Tapinocephalus* zone. Coll. Maddison.

Fig. 54.

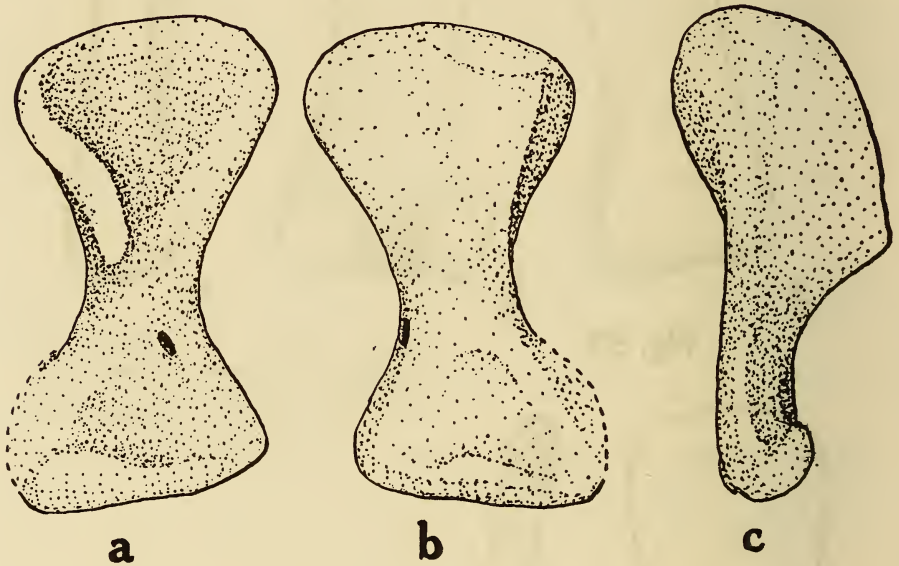
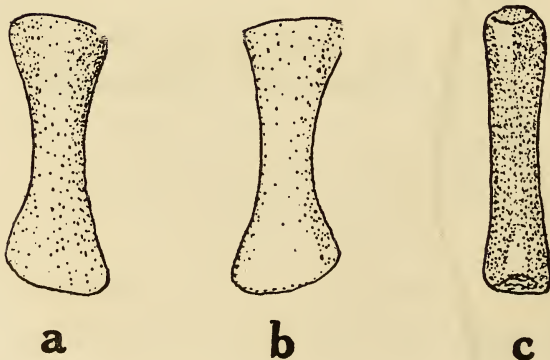


Fig. 55.



Above: Humerus of ? *Moschops*, S.A.M. 9157. ($\times \frac{1}{2}$.)
a. Ventral view. b. Dorsal view. c. Anterior view.

Left: Radius of ? *Moschops*, S.A.M. 9157. ($\times \frac{1}{2}$.) a. Dorsal view. b. Ventral view. c. Posterior view.

S.A.M. 9003. A good isolated scapula (Fig. 53). This scapula is high (540 mm.) with a fairly narrow blade (width 156 mm.) and with its posterior border fairly straight and the glenoid not facing externally. Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 9101. The distal end of a fibula. Rietfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 9124A. A good isolated ulna (Fig. 40 a, a'). Very similar to the ulna of *Moschops capensis*. Voëlfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 9157. A good humerus (Fig. 54), radius (Fig. 55), ulna (Fig. 40 b, b') and part of the carpus.

I (4) have recently described the epipodial and the carpus. The humerus is of medium size (length 384 mm.); the proximal expansion is fairly large (210 mm.) and the distal expansion is moderate (212 mm.); the shaft is fairly wide and short (diams. 91 × 66 mm.); although the ulna is very similar to that of *Moschops* the radius is a much more slender bone. This specimen thus lies near *Moschops*.

Wolwefontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11581. An isolated flattened femur (Fig. 56). This small femur (length 372 mm.) is most probably of a juvenile *Moschops*. Buffelsvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11987. An isolated weathered distal two-thirds of a humerus. The groove on the under surface of the ectepicondyle for the passage of the radial nerve is well developed. Buffelsvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11995. An isolated radius (Fig. 57) with a well-developed proximo-postaxial flange. Stouter than S.A.M. 9157. Sutherland District. Low? *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 3398. An isolated good fibula (Fig. 58). With a length of 252 mm. and its slender build it comes very near that of *Moschops*. Uitkyk, Beaufort West. Low *Tapinocephalus* zone. Coll. Haughton.

Fig. 56.

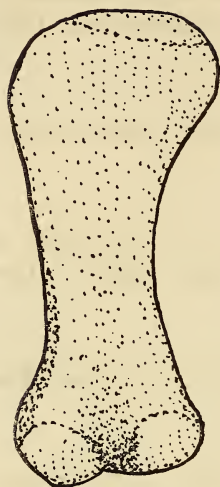


Fig. 57.

**a****b****c**

Above: Radius of ? *Moschops*. S.A.M. 11995.
($\times \frac{1}{8}$.) a. Dorsal view. b. Ventral view.
c. Posterior view.

Left: Femur of ? *Moschops*. S.A.M. 11581.
($\times \frac{1}{8}$.) Ventral view.

Fig. 58.

**a****b****c**

Fibula of ? *Moschops*. S.A.M. 3398.
($\times \frac{1}{8}$.) a. Dorsal view. b. Ventral view.
c. Anterior view.

Titanosuchia

Infra-ordinal Characters of the Girdles and Limbs.

The pectoral girdle is large and massive; the scapula is fairly to very high (530-690 mm.) with the upper part of its blade fairly to very broad

(220-426 mm.); the scapular head of the triceps originates from a fairly to very prominent ridge; the internal opening of the foramen suprecoracoideus opens into the deep subscapular groove, i.e. it crosses the suture between the precoracoid and the scapula; the glenoidal facet of the scapula is large, facing ventro-posteriorly and not, or but little, externally. The coracoidal plate is of great antero-posterior extent. The precoracoid is large and strong, with its anterior border thickened, and its greatly thickened dorso-posterior apex forms at most the anterior depressed rim of the glenoid; the foramen supracoracoideus penetrates the bone very obliquely, so that internally it forms a groove in the sutural face crossing to open into the subscapular groove; the outer precoracoidal face is only moderately convex. The coracoid is massive with its large glenoidal facet facing dorso-posteriorly and also much externally.

These three bones have greatly widened sutural faces near the glenoid, but distally from this corner the bones become abruptly thinner along the sutural lines.

The clavicle is a medium-sized to large bone; flat with expanded ends and a constricted waist.

The cleithrum is a strong element with its upper end expanded and projecting beyond the upper scapular border.

The interclavicle is massive to very massive with a greatly widened stem; broadly spatulate anteriorly, and here curving sharply upwards. In some specimens a ridge along the median line on the dorsal surface of the stem limits the movement of the coracoidal plates. A deep groove receives the posterior edge of the lower end of the clavicle.

The humerus is always massive, but varies in size from fairly small, short and squat to very large and long (312-575 mm.); an ectepicondylar foramen is always present; the radial condyle is always strong, thick and well modelled and extends far proximally along the ventral face, in some cases nearly reaching the base of the delto-pectoral crest; the processus medialis lies either nearly in the same plane as the caput or in a more distal plane, i.e. it is proximally or not proximally situated; the processus lateralis is always situated far proximally; the proximal expansion is relatively moderately or very great; the epicondyles are greatly expanded; the shaft is either fairly long or very short, fairly slender or very broad; the ventral opening of the entepicondylar foramen is slitlike or broadly oval; except in one case, the delto-pectoral crest is long; the ectepicondylar foramen is always small and circular.

The ulna is large and massive (length 320-402 mm.).

The radius is large and massive (length 282-318 mm.).

The manus is unknown.

The pelvis has a short pubo-ischiadic plate; the iliac blade is high; the ilio-fibularis ridge is rounded and strong and usually lies vertically; the supra-acetabular buttress is strong with a well-developed notch; the acetabulum faces outwards; the anterior iliac process is moderately to strongly everted; the posterior iliac process is fairly short and high; the iliac blade is concave in antero-posterior direction.

The femur is large and massive (length 498-605 mm.) with the internal trochanter developed as a strong rounded tubercle, situated well away from the preaxial border; the width over the external trochanter, which sometimes has a notch separating it from the proximal face, is great (234-306 mm.).

The tibia is large and massive with strongly expanded ends (length 255-355 mm.).

The fibula is large and stout with a deeply concave anterior face (length 235-345 mm.).

The pes is incompletely known.

Titanosuchidae

Family Characters of the Girdles and Limbs.

The Titanosuchid pectoral girdle is only adequately known in one genus. The pectoral girdle is large and massive; the height is 860-890 mm., and the length of the coracoidal plate is 560-580 mm., which is thus 62-67% of the height. The scapula is high (680 mm.) and the upper end of the blade is broad to very broad (372-426 mm.); the scapular head of the triceps is attached to a sharp ridge or a prominent mound.

The precoracoid is large and massive (340 × 342 mm.).

The coracoid is of medium size but massive (250 × 252 mm.).

The clavicle is a large bone (length 505 mm.); it is medio-laterally flattened, with expanded dorsal and ventral ends, but the waist not greatly constricted; the ventral spatulate end curves inwards to fit over the outer face of the upturned antero-lateral corner of the interclavicle; the dorsal end has its anterior end greatly thickened and is produced dorsally as a short, strong process, which presumably fits into a groove on the lower end of the cleithrum, which is however not preserved.

The interclavicle is a large and massive bone; the length is 570 mm.; width over anterior expansion 455-545 mm.; width over posterior end of stem 215-310 mm. and over the waist of the stem 155-180 mm.; the lateral horns have a thickened postero-lateral edge, anterior to which there is a fairly deep groove to house the ventro-posterior edge of the spatulate end of the clavicle.

The humerus is long and large (length 480-575 mm.); the radial condyle, although strong and extending far along the ventral face, does not reach the plane of the entepicondylar foramen, and lies well distal of the base of the delto-pectoral crest; the processus medialis always lies far proximally — nearly in the same plane as the caput; the proximal expansion is moderately great (240?-310 mm.); the shaft is fairly long and relatively not very broad; the ventral opening of the entepicondylar foramen slitlike or oval.

The ulna has a short massive shaft and a long sigmoid face with a rounded lip.

The radius is a long robust bone.

In the massive pelvis the upper edge of the ilium does not slope strongly downwards in posterior direction; the anterior process is moderately everted; the ilio-fibularis ridge is massive; the ilium forms much the greater part of the acetabulum.

The femur is very large (length 564-605 mm.); the width over the external trochanter is great (275-306 mm.); the preaxial face moderately to deeply concave.

The tibia and fibula large and strong.

Genus *Titanosuchus* Owen

The pectoral girdle poorly known; the coracoid is massive with the glenoidal facet facing much externally.

The humerus is very large (length 530 mm.); the shaft is short and wide (130 mm.); the width over the proximal expansion is 308 mm.; the delto-pectoral crest is fairly short and its extremity is knoblike; the processus medialis is situated well proximally; the capitellum is strong and extends far proximally along the ventral face of the bone; the opening of the entepicondylar foramen ventrally is slitlike; the ectepicondyle is developed as a fairly thin sheet of bone and the foramen is situated well away from the edge of the bone.

The epipodial bones and the manus are unknown.

The pelvic girdle is unknown.

The femur is very long (605 mm.); the width over the external trochanter is 275 mm.; the shaft is fairly narrow (135 mm.); the preaxial face is not very deeply concave, but the caput is preaxially directed.

The fibula is large and massive (295 mm.).

The tibia and pes are not known.

Titanosuchus ferox Owen

The specific diagnosis is as for the genus (see Seeley's (28) plates).

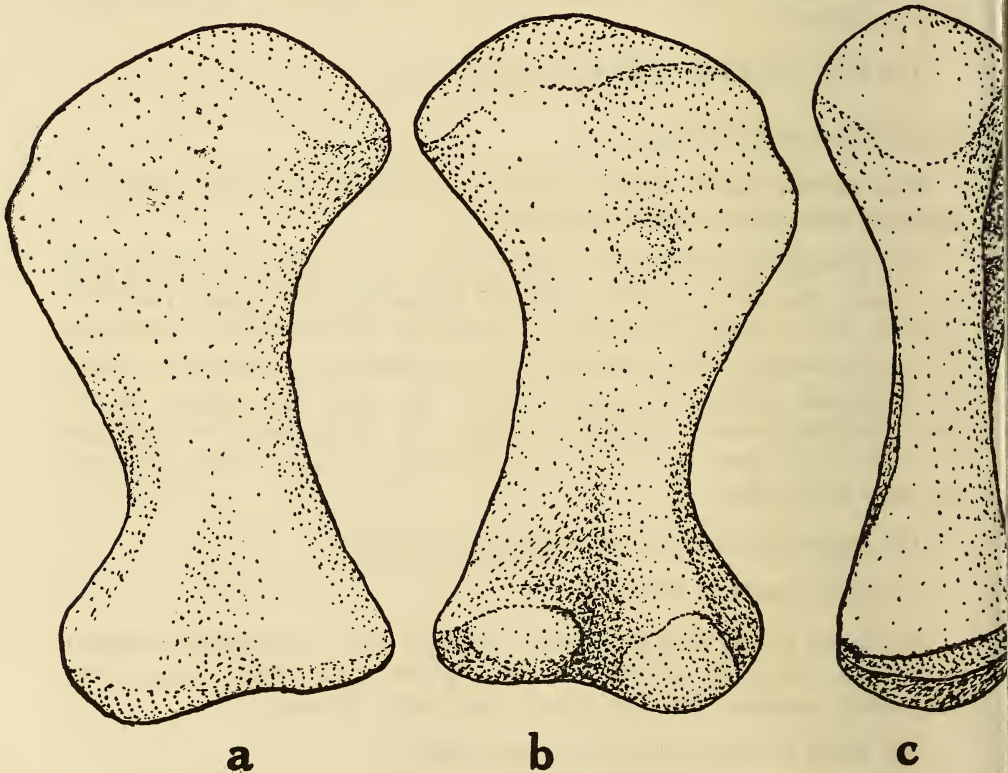
B.M. 49367, coracoid; 49369, humerus; 49368, femur; and 49367b, fibula; all said to be associated with the type cranial material. Koedoeskop, Beaufort West. Mid *Tapinocephalus* zone. Coll. T. Bain.

Referred specimens in the S.A.M. collection:

S.A.M. 739. A fairly good isolated femur, with a length of 570 mm. and shaft diameters of 157×65 mm. Beaufort West District. *Tapinocephalus* zone. Coll. Oakley.

S.A.M. 11491. A good isolated right femur (Fig. 59) with a length of 546 mm.; 294 mm. over the external trochanter, which is separated from the proximal face by a distinct notch; the shaft diameters are 144×84 mm. Mynhardtskraal, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 59.



Femur of *Titanosuchus ferox*. S.A.M. 11491. ($\times \frac{1}{2}$.) a. Dorsal view. b. Ventral view. c. Anterior view.

Genus *Scapanodon* Broom

All that is known of the pectoral girdle is a single incomplete scapula which shows that the scapular head of the triceps originated from a sharp ridge on the posterior face of the scapula just above the glenoid.

The humerus is fairly long to long (480?-522 mm.); the proximal expansion is not very great (240-264? mm.); the distal expansion fairly great (282-290? mm.); the shaft is fairly short to long and not very broad (diams. 114-118 × 110-121 mm.); the delto-pectoral crest is long with its extremity extending to fairly near the entepicondylar foramen or terminating well proximally of this plane; the caput is oval and fairly massive and lies in nearly the same plane as the processus medialis, which is thus well proximally situated; the twist on the shaft is great (40°); the L.M.L. is strong, forming a pronounced bulge on the dorsal surface of the shaft; the A.D.V.L. is strong and sharp; the entepicondyle is developed as a moderately thick, but not greatly flaring flange of bone, with the foramen ventrally showing a slitlike opening not very far removed from the edge of the bone; the ectepicondyle is a greatly flaring thin sheet of bone pierced vertically by the foramen lying well removed from the edge of the bone.

The epipodial bones of the forelimb and the manus are not known.

The pelvic girdle is massive and high; the pubo-ischiadic plate is short (80% of the height of the pelvis as restored); the supra-acetabular part of the ilium is high and relatively short (the height is 74% of the antero-posterior length); the anterior iliac process, although not fully preserved, appears to have been fairly short, but fairly high, and it is only moderately everted; the posterior iliac process is short and has its posterior edge directed much upwards and this edge is folded over to form a massive ilio-fibularis ridge, which forms a prominent feature on the outer iliac face; anterior to this ridge the iliac blade is deeply concave where the gluteal muscle is attached; the inner face of the anterior process is irregularly pitted for the reception of a rib lying anterior to the main sacral rib; the iliac portion of the acetabulum is very great, forming over two thirds of the acetabulum.

The antero-ventral edge of the pubis is strongly everted with the tuberculum pubis confluent with the strongly thickened outwardly directed antero-ventral edge, which thins as it proceeds towards the median line. The pubic symphysis must have been short and weak. The pubic foramen is a large oval opening.

Only the upper half of the ischium is preserved; it forms only a small part of the acetabulum; its postero-dorsal edge is greatly thickened and it would appear that the ischial symphysis was weak.

The femur is massive and long (564 mm.); its proximal expansion is great, with the width over the external trochanter, which has a notch

separating it from the proximal face, 306 mm.; the preaxial face is fairly strongly concave with the caput moderately thick (134 mm.) and directed moderately preaxially; the shaft is fairly long but very broad (162 mm.); the preaxial condyle is much weaker than the postaxial condyle, which also lies further distally and is very massive (174 mm. thick); the femoro-tibialis ridge is strong, but not strongly bulging on the dorsal surface of the shaft.

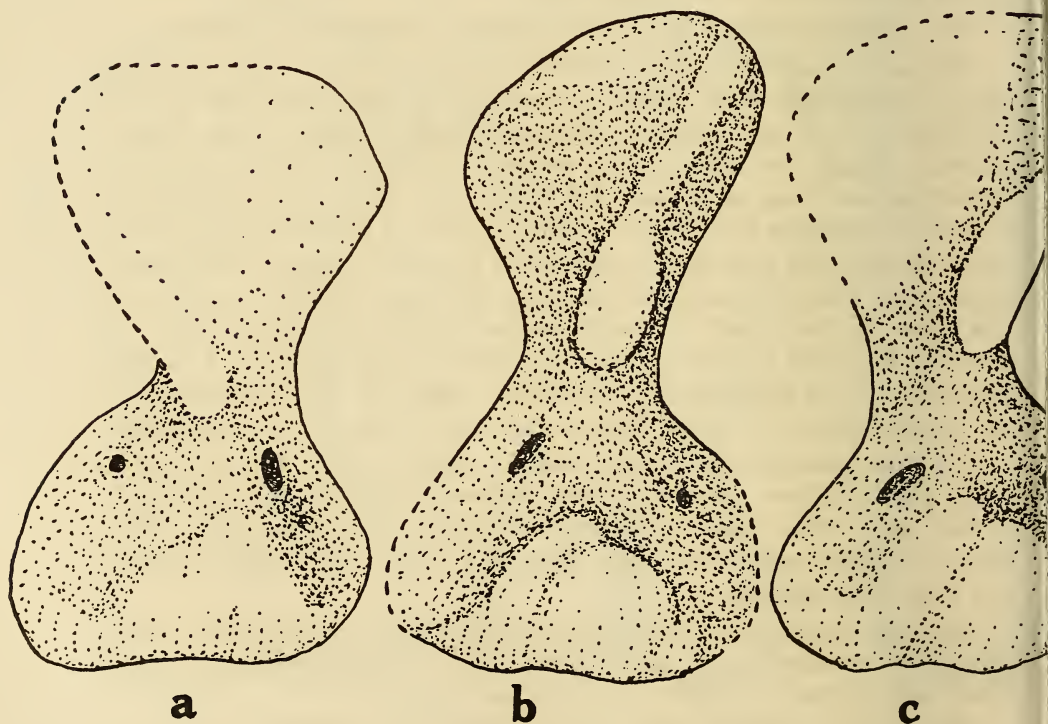
No tibia, fibula or pes is known.

Scapanodon duplessisi Broom

Of the girdle and limb-bones only the humerus is known. The humerus is long (520-522 mm.); the delto-pectoral crest with a swollen end terminates well proximally of the entepicondylar foramen.

S.A.M. 772 and 773. Two fairly good left humeri (Fig. 60 b and c) said to be associated with the poor type jaws. Seekoeigat, Prince Albert. High *Tapinocephalus* zone. Coll. du Plessis.

Fig. 60.



Humeri in ventral view. ($\times \frac{1}{2}$.) a. *Scapanodon septemfontis*. S.A.M. 5001. b. *Scapanodon duplessisi*. S.A.M. 772. c. *Scapanodon duplessisi*. S.A.M. 773.

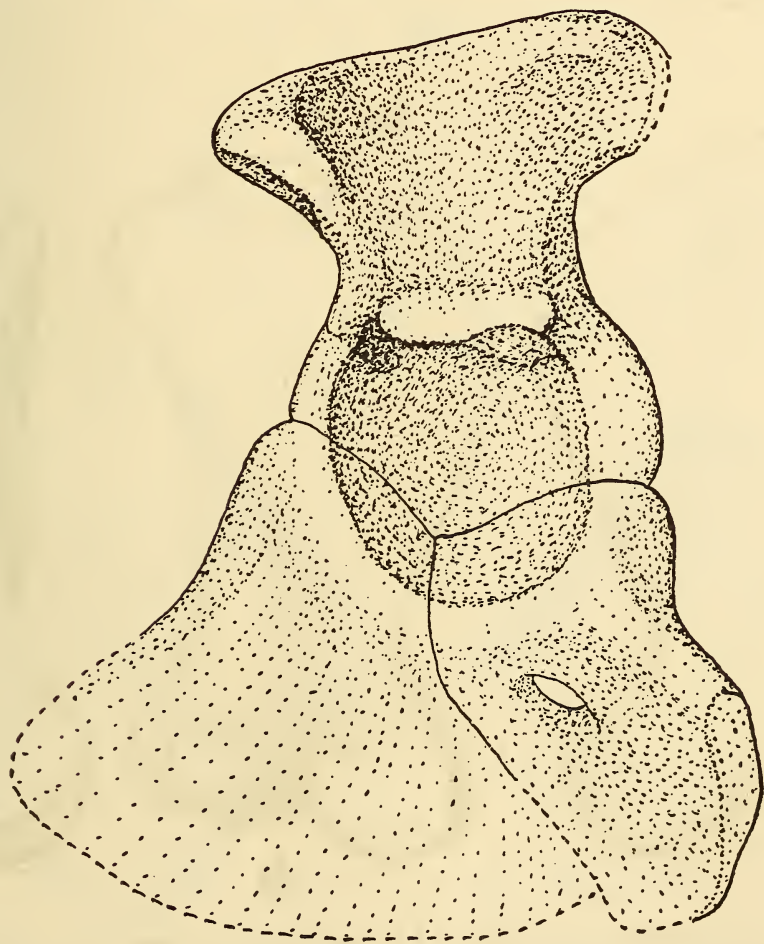
Scapanodon septemfontis Sp. Nov.

I am making the specimen (S.A.M. 5001), which Broom (13) erroneously described as being referable to *Tapinocephalus atherstonei*, the type of a new species of *Scapanodon*.

Nothing is known of the pectoral girdle.

The humerus is large and fairly long (480? mm.); the delto-pectoral crest terminates far distally, but still well away from the ventral opening of the entepicondylar foramen.

Fig. 61.



Pelvis of *Scapanodon septemfontis*. S.A.M. 5001. ($\times \frac{1}{4}$.) Lateral view.

The rest of the forelimb is unknown.

The pelvis and femur are as described in the generic diagnosis.

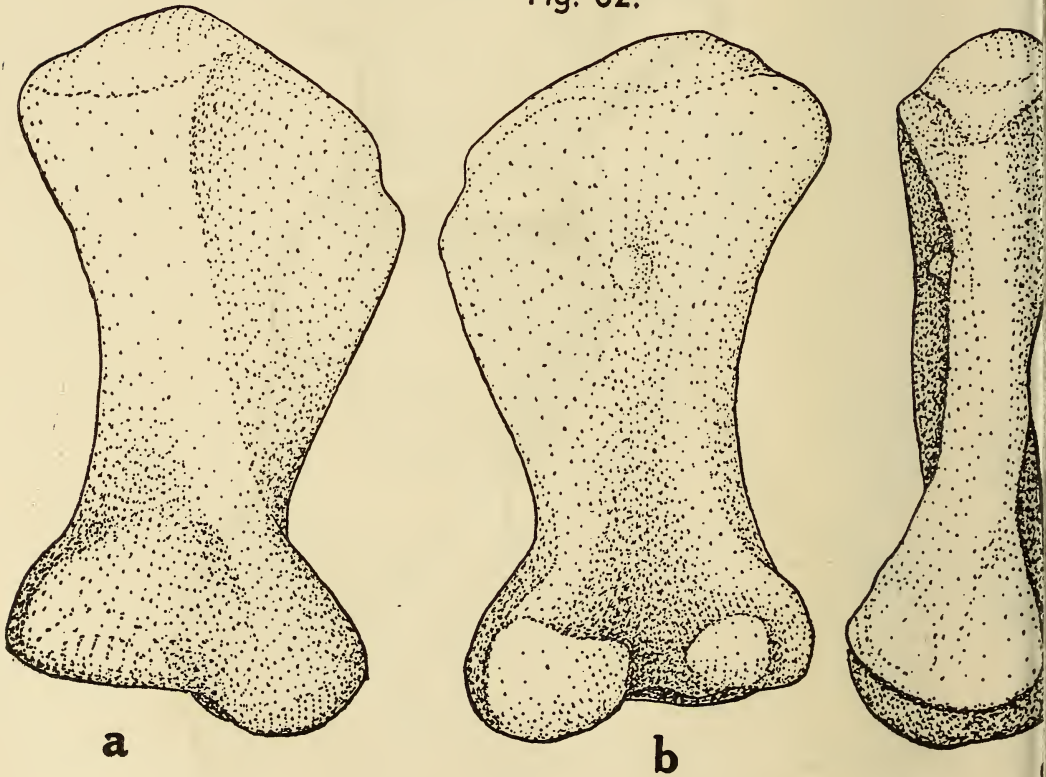
Type: S.A.M. 5001. An incomplete humerus (Fig. 60a), a nearly complete pelvis (Fig. 61) and a good femur (Fig. 62). Sewefontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

Referred specimens in the S.A.M. collection:

S.A.M. 1203. A pubis. Letjiesbos, Beaufort West. Mid *Tapinocephalus* zone. Coll. Maddison.

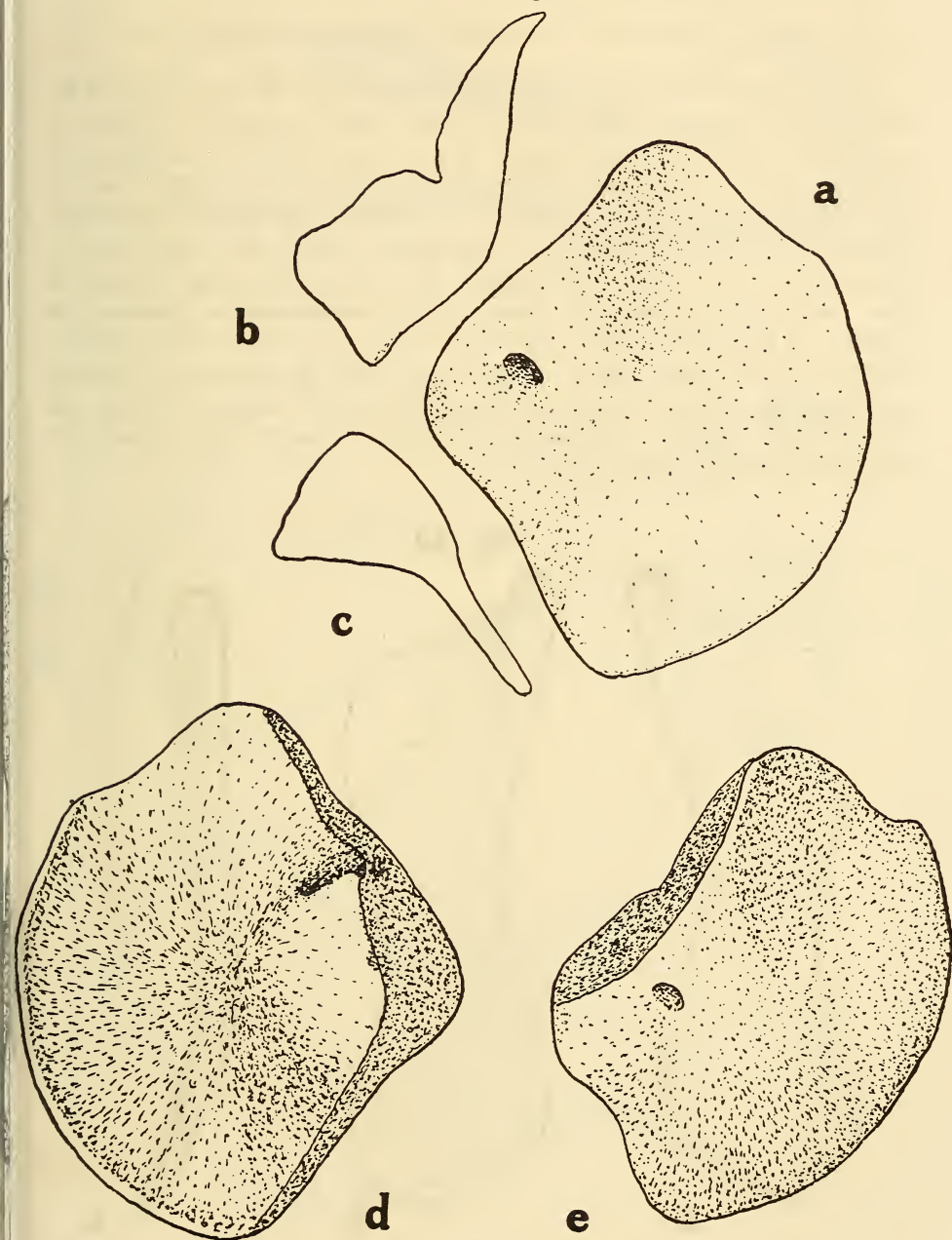
S.A.M. 11578. Part of a scapula and the major part of a humerus. Aasvoëlbos, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 62.



Femur of *Scapanodon septemfontis*. S.A.M. 5001. ($\times \frac{1}{4}$). a. Dorsal view. b. Ventral view. c. Anterior view.

Fig. 63.



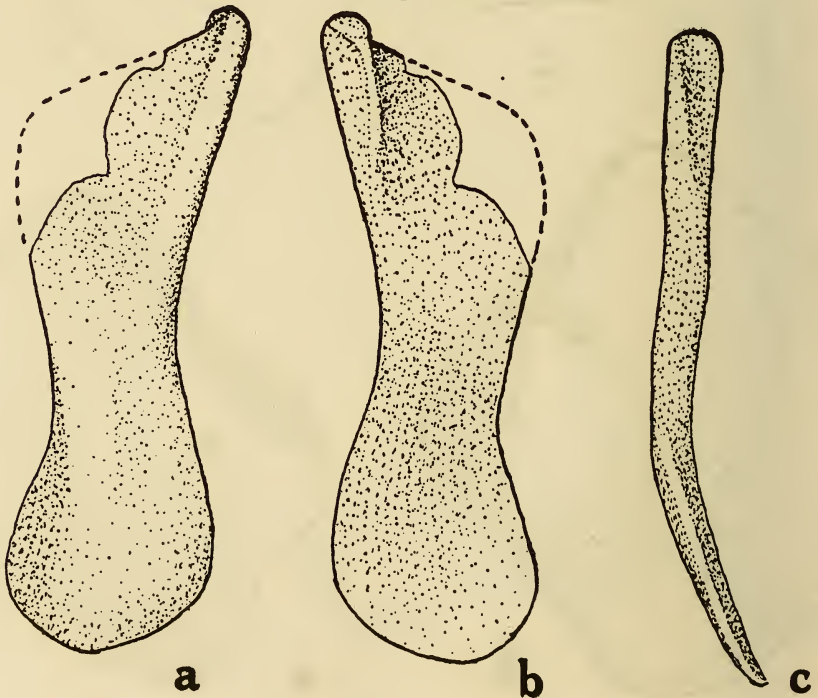
Precoracoid of *Parascapanodon avifontis*. S.A.M. 9127. ($\times \frac{1}{6}$.) a. Outer view.
b. Outline of sutural face for the scapula. c. Outline of sutural face for the coracoid.
d. Inner view. e. Lateral view (as projected on to the median plane).

Genus *Parascapanodon* Gen. Nov.

The generic characters of the pectoral girdle are as described for the family.

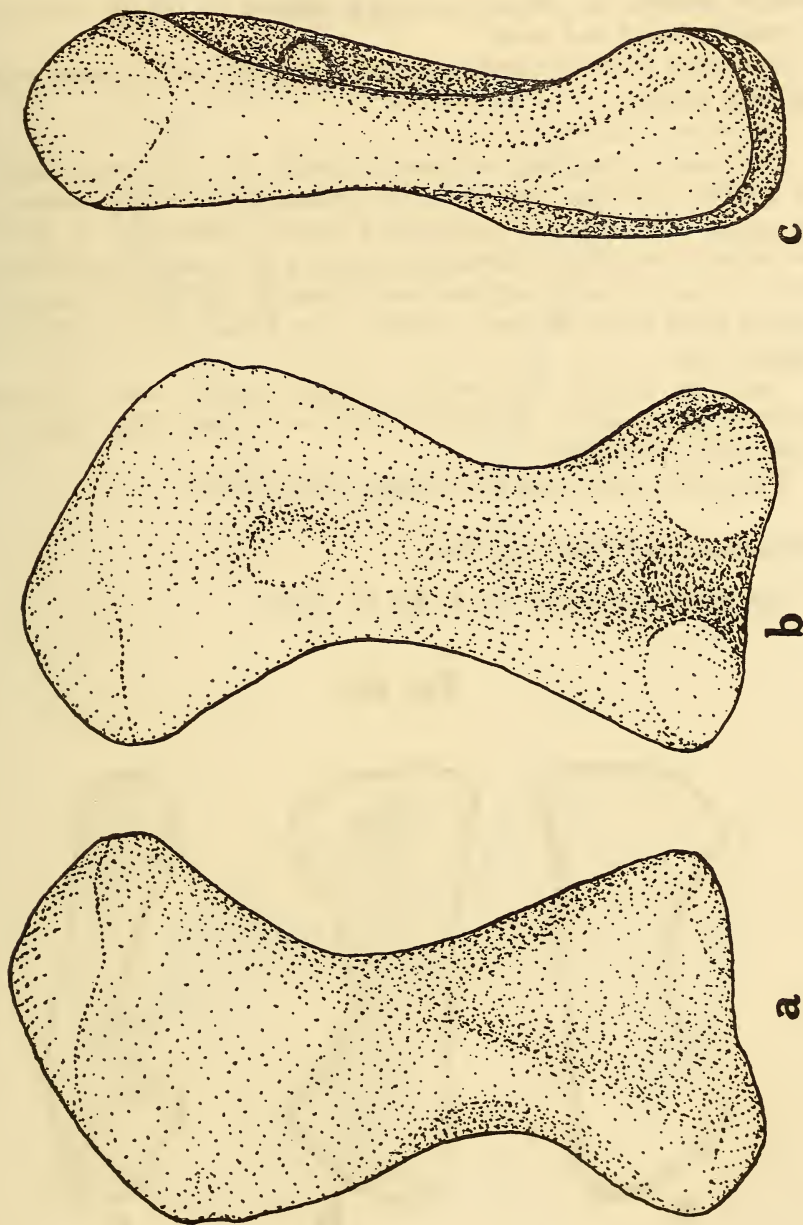
The humerus is very large and massive; the length is 575 mm. and the ends greatly expanded (proximal 310? mm., distal 312 mm.); the shaft is fairly long but very robust (diams. 144 × 142 mm.); the delto-pectoral crest is long, but terminates well proximal of the plane in which the entepicondylar foramen lies; the caput is very massive, but short; the processus medialis lies just a little distally of the plane in which the caput lies; the capitellum is very strong and massive and extends far along the ventral face, but does not reach the plane of the entepicondylar foramen; the "twist" on the shaft is large (40°); the L.M.L. is strong, with a massive swelling on the dorsal surface of the shaft; both epicondyles are strongly developed; the ventral opening of the entepicondylar foramen is large and broadly oval, and the ectepicondylar foramen is small and situated well away from the edge of the bone.

Fig. 64.



Right clavicle of *Parascapanodon avifontis*. S.A.M. 9127. ($\times \frac{1}{4}$.) a. Outer view. b. Inner view. c. Anterior view.

Fig. 65.



Femur of *Parascapanodon avifontis*. S.A.M. 9127. ($\times \frac{1}{2}$) a. Dorsal view. b. Ventral view. c. Anterior view.

The ulna is a large and massive bone (length 372 mm., width over the coronoid process is 200 mm.); the sigmoid face is long, with its ventral part broadly rounded; the coronoid process is situated far distally and the shaft is massive, broad and short.

The radius is a long robust bone (length 294 mm.) with a strong proximo-postaxial flange.

No pelvis is known.

The femur is very long and massive (length 595 mm.); very broad over the external trochanter (300 mm.); the preaxial face is deeply concave, with the caput much preaxially directed and massive (diams. 215×167 mm.); the external trochanter is indistinctly separated by a notch from the proximal face; the shaft is fairly long and broad (breadth 150 mm.); wide over the massive distal facets; the area of origin of the femoro-tibialis forms a strong bulging ridge.

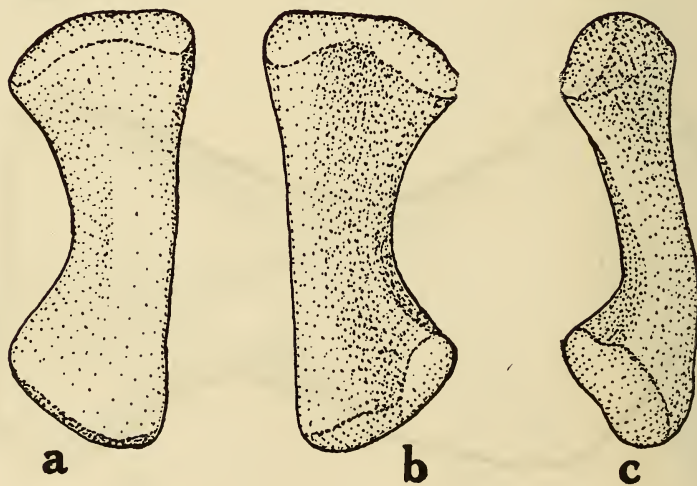
The tibia is large and massive (length 330-355 mm.); the cnemial eminence very massive, continued distally as a strong ridge, with a deep groove lying postaxially.

The fibula is large and stout (length 330-345 mm.).

Parascapanodon avifontis Sp. Nov.

The specific characters are as for the genus.

Fig. 66.



Left fibula of *Parascapanodon avifontis*. S.A.M. 9127.
($\times \frac{1}{4}$.) a. Dorsal view. b. Ventral view. c. Anterior view.

Fig. 67.



Scapulo-coracoid of *Parascapanodon avifontis*, S.A.M. 9106. ($\times \frac{1}{4}$)
Lateral view.

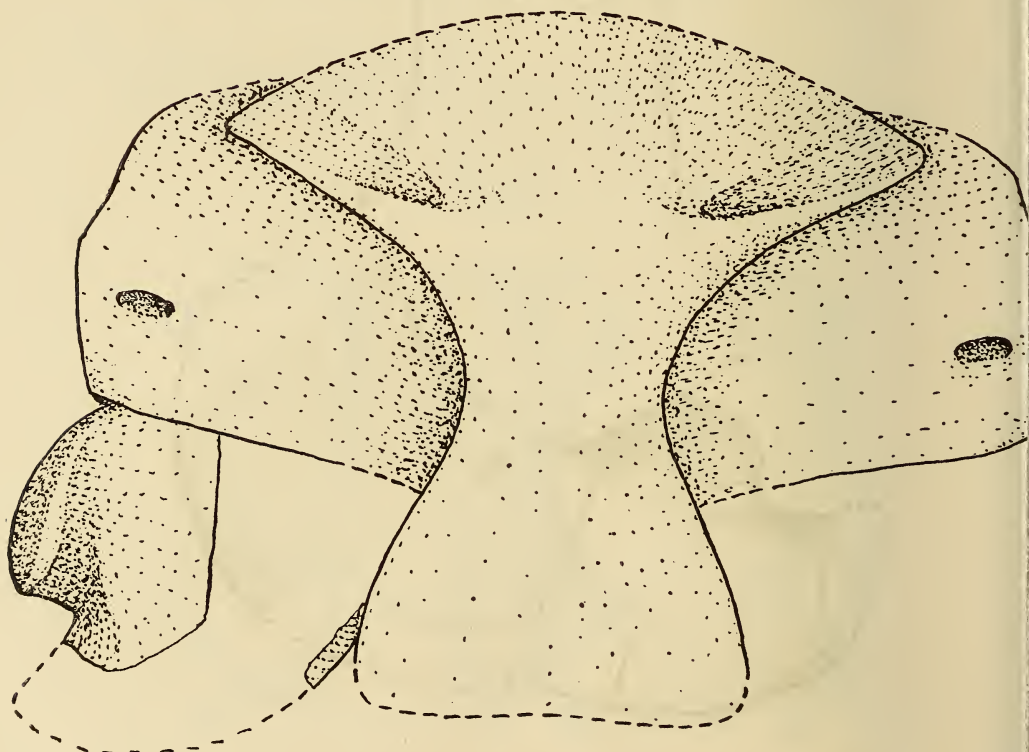
Type: S.A.M. 9127. A very good precoracoid (Fig. 63), a good clavicle (Fig. 64), a good femur (Fig. 65), a well-preserved fibula (Fig. 66), associated with parts of a large skull. Voëlfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

Paratypes: Although lacking cranial parts, and direct comparison with the type skull parts thus impossible, I have used the following specimens in drawing up the generic description of *Parascapanodon*:

S.A.M. 9106. Parts of the scapula, coracoid and precoracoid (Fig. 67). Veldmansrivier, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

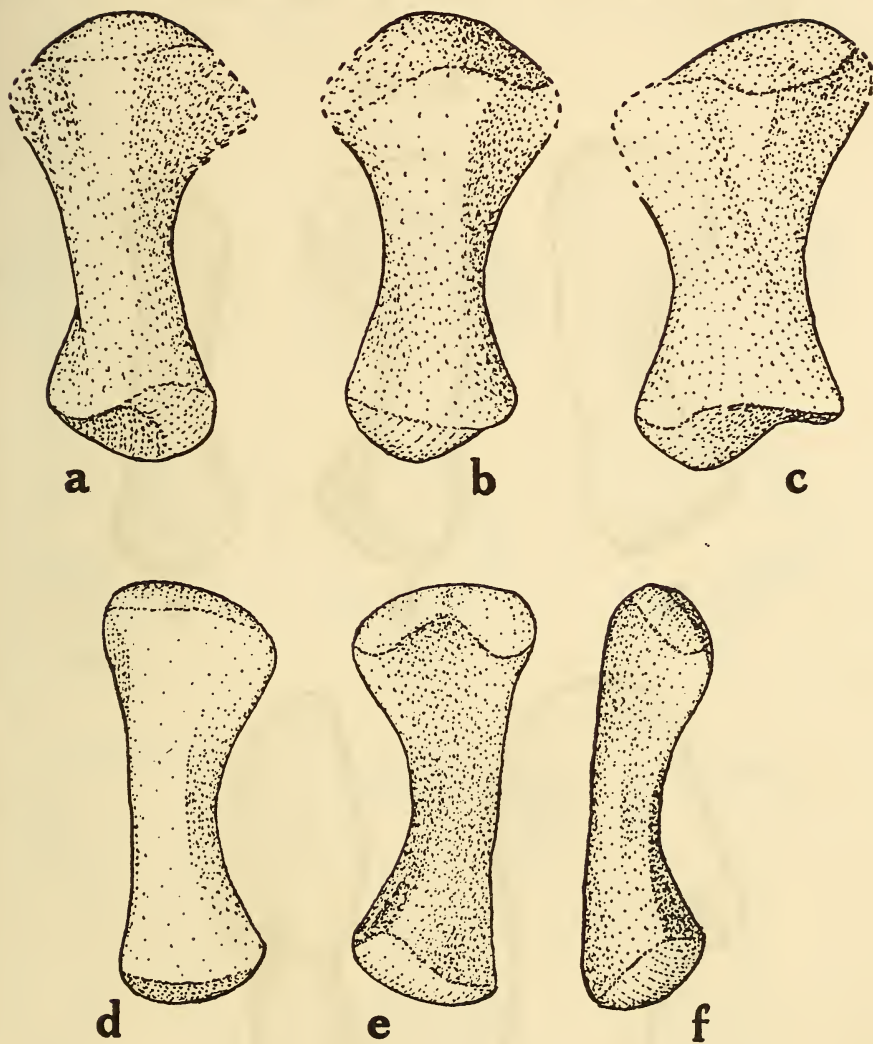
S.A.M. 11488. Parts of the precoracoid, coracoid and interclavicle (Fig. 68) and a tibia (Fig. 69 a-c) and fibula (Fig. 69 d-f). Voëlfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 68.



Interclavicle, precoracoid and coracoid of *Parascapanodon avifontis* in ventral view. S.A.M. 11488. ($\times \frac{1}{8}$.)

Fig. 69.

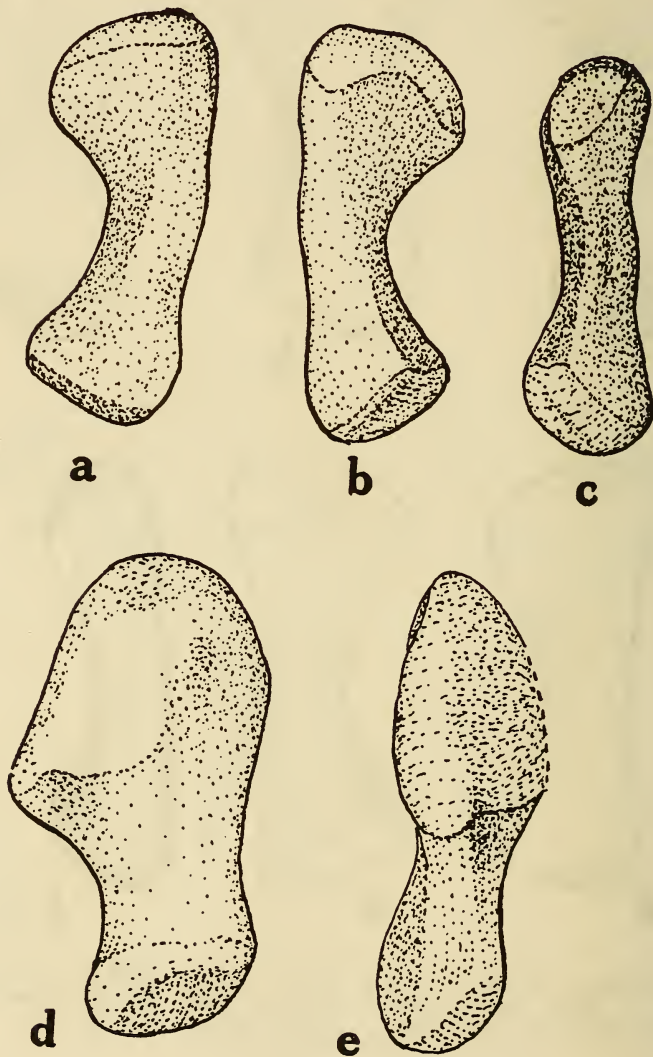


Parascapanodon avifontis. S.A.M. 11488. ($\times \frac{1}{6}$.) a. Right tibia in dorsal view. b. Right tibia in ventral view. c. Right tibia in posterior view. d. Right fibula in dorsal view. e. Right fibula in ventral view. f. Right fibula in anterior view.

These two specimens are included in this species on the ground of the great similarity of their precoracoids to that of the type.

On the similarity of its fibula to that of the type I have also included:
S.A.M. 9163. A good fibula (Fig. 70 a-c) and a fair ulna (Fig. 70 d-e).
Wakkerstroom, Prince Albert. Low *Tapinocephalus* zone. Coll.
Boonstra.

Fig. 70.

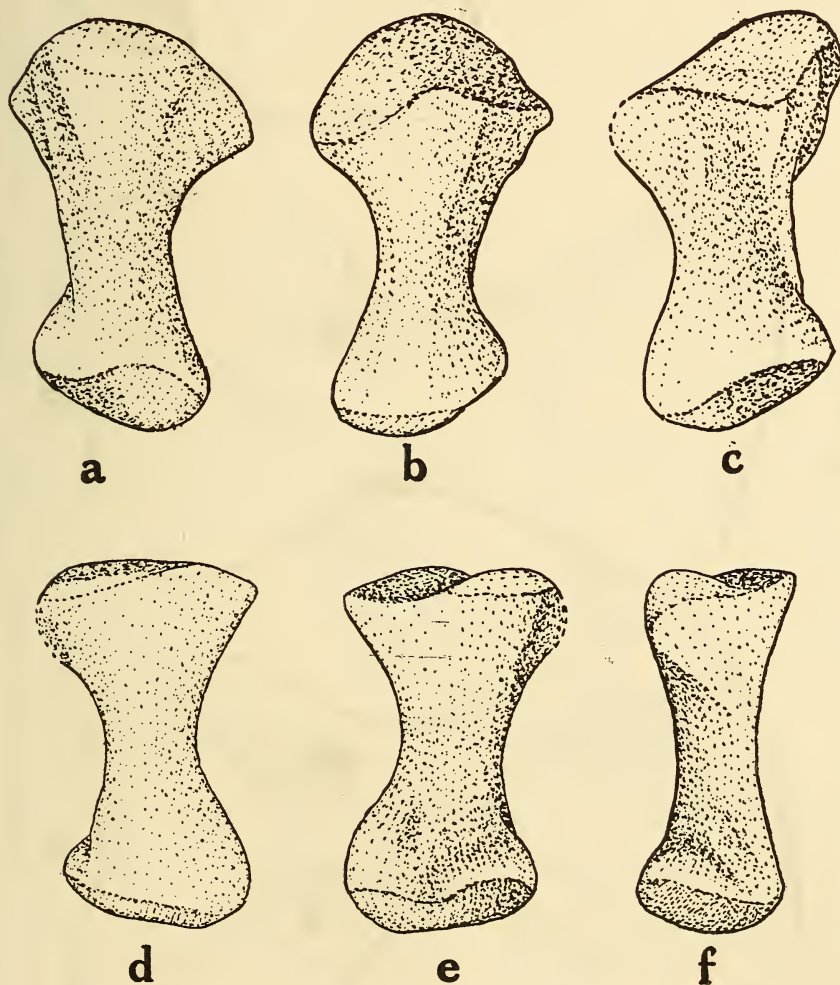


Parascapanodon avifontis. S.A.M. 9163. ($\times \frac{1}{2}$.) a. Left fibula in dorsal view. b. Left fibula in ventral view. c. Left fibula in anterior view. d. Left ulna in dorsal view. e. Left ulna in anterior view.

On the similarity of its tibia to that of S.A.M. 11488 I have also included:

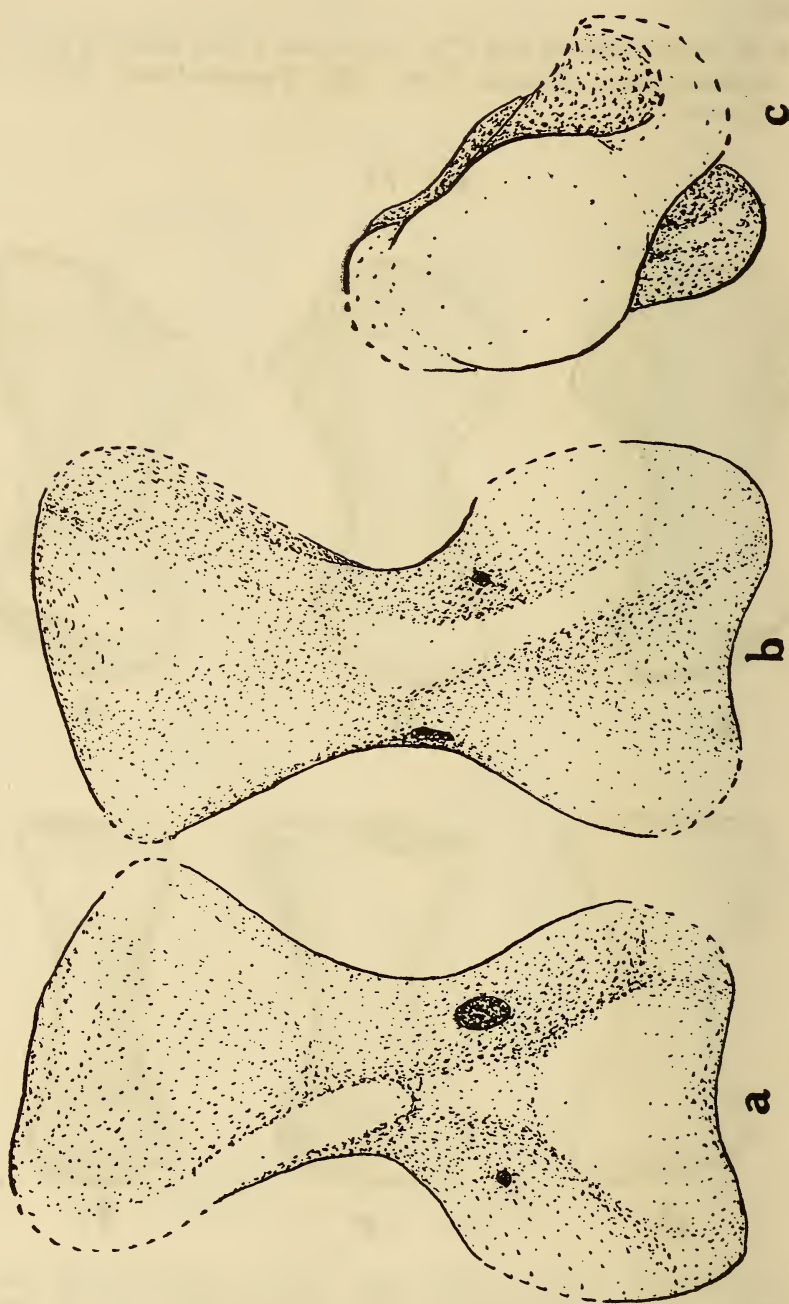
S.A.M. 11299. A good tibia (Fig. 71 a-c) and a good radius (Fig. 71 d-f).
 Boesmansrivier, Beaufort West. Mid *Tapinocephalus* zone. Coll.
 Boonstra.

Fig. 71.



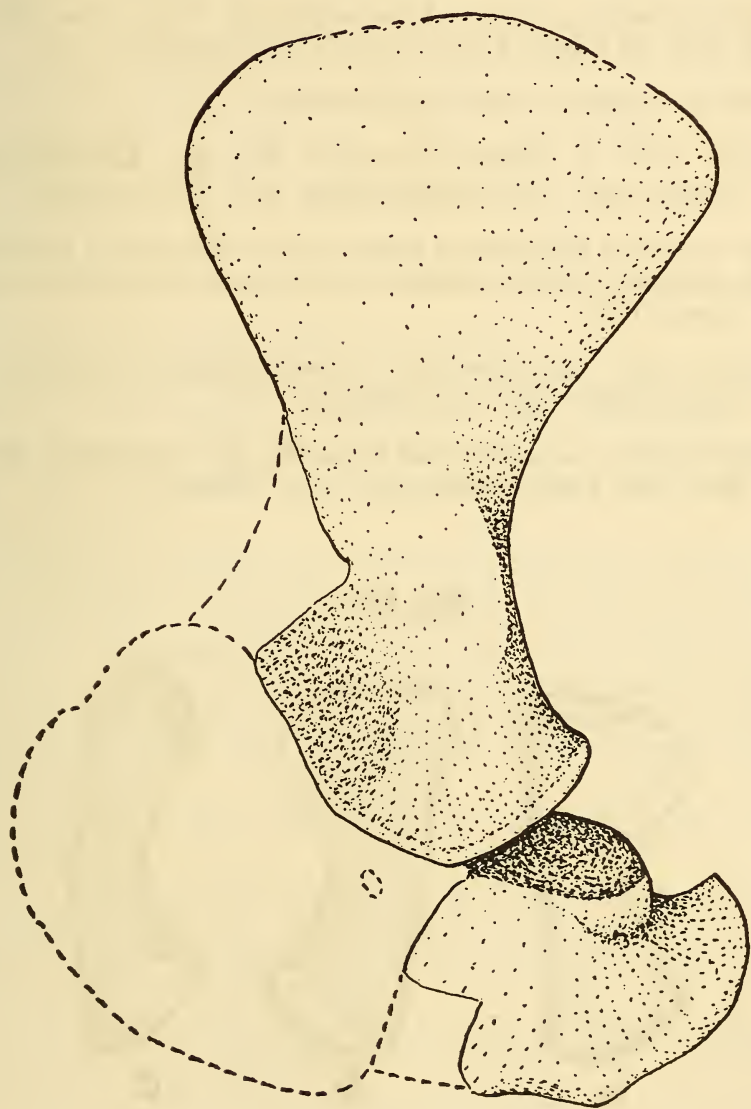
Parascapanodon avifontis. S.A.M. 11299. ($\times \frac{1}{6}$) a. Right tibia in dorsal view. b. Right tibia in ventral view. c. Right tibia in posterior view. d. Right radius in dorsal view. e. Right radius in ventral view. f. Right radius in posterior view.

Fig. 72.



Humerus of *Parascapapocodon avifontis*. S.A.M. 11881. ($\times \frac{1}{2}$) a. Ventral view.
b. Dorsal view. c. Proximal view.

Fig. 73.



Scapulo-coracoid of *Parascapanodon*. S.A.M. 9010. ($\times \frac{1}{6}$.)
Lateral view.

I am including the following isolated humerus as a paratype:

S.A.M. 11881. A fairly good isolated humerus (Fig. 72). Bloukrans, Prince Albert. Mid *Tapinocephalus* zone. Coll. Boonstra.

This very large and massive humerus can only be associated with such a large skull and massive femur as that of *Parascapanodon*.

Referred specimens in the S.A.M. collection:

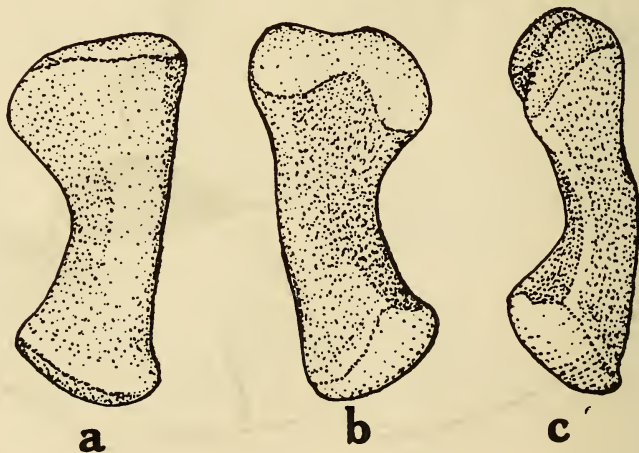
S.A.M. 9010. A scapula and coracoid (Fig. 73). Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

The coracoid in this specimen agrees very well with that of the paratype S.A.M. 9106 and I am thus referring it to this genus although it has a much wider scapular blade.

S.A.M. 11938. An isolated tibia. Steenboksfontein, Laingsburg. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11989. An isolated good fibula (Fig. 74). Koedoeskop, Beaufort West. Mid *Tapinocephalus* zone. Coll. Boonstra.

Fig. 74.



Fibula of *Parascapanodon*. S.A.M. 11989.
($\times \frac{1}{2}$.) a. Dorsal view. b. Ventral view.
c. Anterior view.

Jonkeridae

Family Characters of the Girdles and Limbs.

The pectoral girdle is large and massive; the height is 650-780 mm. and the length of the coracoidal plate is 385-534 mm., which is thus 59-68% of the height. The scapula is fairly high to high (530-665 mm.) and the upper end of the blade is fairly broad (220-360 mm.); the scapular head of the triceps is attached to a low or a prominent mound.

The precoracoid is fairly large, but not very massive (315-330 × 235-270 mm.).

The coracoid is small to medium-sized, but massive (180-200 × 220-282 mm.).

The clavicle is a large bone (420?-520? mm.) with a greatly constricted waist.

The cleithrum is strong (length 450? mm.).

The interclavicle is a large and massive bone; the length is 396-558 mm.; width over anterior expansion 292-456 mm.; width over posterior end of the stem 210-252 mm. and over the waist of the stem 96-180 mm.; the lateral horns with thickened postero-lateral edge and a deep groove to receive the clavicle.

The humerus is relatively short and small to fairly large (length 312-510 mm.); the capitellum is very strong and extends far along the ventral face to reach the plane of the entepicondylar foramen, and sometimes even the base of the delto-pectoral crest; the processus medialis always lies well distally — in a plane well distal of that of the caput; the proximal expansion is relatively great (222-366 mm.); the shaft is short and broad to very broad (breadth 84-168 mm.); the ventral opening of the entepicondylar foramen is large and oval.

The ulna has a long, fairly massive shaft, and the radius is a long robust bone.

In the pelvis the upper edge of the ilium slopes strongly downwards in posterior direction; the anterior process is strongly everted; the ilio-fibularis ridge is fairly light to moderately massive; the ilium does not form the greater part of the acetabulum.

The femur is not large (length 504 mm.); the width over the external trochanter fairly large (264 mm.).

The tibia and fibula fairly large but fairly slender.

Genus *Jonkeria* van Hoepen

The generic characters are as for the family.

Jonkeria truculenta van Hoepen

In our collection there are no specimens of this species with elements of the girdles and limbs preserved. The following specific characterisation is thus drawn from Broom's (14) account.

Scapula fairly high (530 mm.) and the blade fairly wide (220 mm.); the glenoidal facet faces somewhat externally. The precoracoid just enters the glenoid; it is high (315 mm.) and fairly long (235 mm.); the anterior edge is thin. The coracoid is 200 mm. high and 220? mm. long. The cleithrum is, according to Broom, small and probably fairly similar to that of *Moschops*. Length of clavicle $\pm$ 520 mm. Interclavicle has a probable length of 520 mm., width anteriorly 360 mm., width of stem 120-240 mm.

Humerus, ulna, radius, manus, pelvis and femur unknown.

Length of tibia 248 mm., and of fibula 240 mm.

The intermedium is strong and the fibulare a thin bone.

Type: Transv. Mus. 212. Right scapulo-coracoid, right and part of left clavicle, part of the right cleithrum, part of interclavicle, right tibia, fibula, intermedium and fibulare, associated with a good skull. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. van Hoepen.

Jonkeria angusticeps (Broom)

In our collection there is no specimen referable to this species. Broom's (14) figure of the ischium of the type is very misleading. With our increased knowledge it is now evident that of the ischium figured by Broom nearly half of the bone, viz. that part forming the contact with the pubis, is missing and what Broom figured was the dorso-posterior part only.

Type: A.M.N.H. 5633. A very imperfect ischium, associated with a good lower jaw. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. van der Byl.

Jonkeria crassus (Broom)

With no specimen in our collection the following characterisation is extracted from Broom's (14) account.

The scapula is simply mentioned but not described by Broom.

The humerus is relatively short (440 mm.), very massive, with greatly expanded ends (proximal 345 mm. and distal 322 mm.); the shaft is very short and broad (135 mm.); the delto-pectoral crest is very long and powerful and nearly reaches the plane of the entepicondylar foramen; the caput is

widely oval; the processus medialis lies well distal of the plane of the caput; the capitellum is strong, thick and well modelled and extends very far proximally along the ventral surface right up to the plane of the entepicondylar foramen; the L.M.L. is strong with a strong swelling on the dorsal surface of the shaft; the entepicondyle is very strongly developed as a thick flange, with the ventral opening of the foramen large and broadly oval, and it lies well away from the edge of the bone, nearly under the base of the deltopectoral crest; the ectepicondyle is developed as a thick sheet of bone, pierced obliquely by the small rounded foramen lying near the edge of the bone.

The ulna is massive; the width over the coronoid process is 217 mm.

The ilium is not figured or described by Broom.

Type: A.M.N.H. 5577. Scapula, humerus, part of ulna and ilium, associated with the dentaries. Kruidfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. van der Byl.

Jonkeria haughtoni (Broom)

With about a dozen specimens in the collection a fairly full characterisation of this species can be given.

The scapula is high to very high (590-665 mm.), with the upper part of the blade broad to very broad (300-360 mm.); the tricipital ridge is fairly to quite prominent; the glenoidal facet of the scapula faces mainly postero-ventrally and but slightly outwards; the precoracoid forms the anterior part of the rim of the glenoid. The massive coracoid has a large glenoidal facet facing much externally.

The clavicle is represented by the upper half of the right clavicle; the upper end is moderately expanded (less than in *Parascapanodon*), with its antero-dorsal corner produced as a process, which overlies the lower end of the cleithrum, fitting into a groove in that bone, it has a strongly constricted waist and its lower end is probably well expanded.

The cleithrum is a long (440? mm.) fairly slender bone, with its dorsal end spatulate; in its lower half the posterior two-thirds of the outer face is grooved for the reception of the clavicle; the inner face is excavated along its posterior edge and in this recess the edge of the scapula fits. The cleithrum extends dorsally of the upper edge of the scapula.

The interclavicle is not preserved.

The humerus is massive but fairly short (456 mm.); the proximal expansion is very great (width 324 mm.) and the distal end is also wide (306 mm.); the shaft is very short and very broad (diams. 168 × 114 mm.);

the delto-pectoral crest is very long and nearly reaches the plane of the entepicondylar foramen; the caput is oval in outline; the processus medialis lies in a plane well distally of the plane in which the caput lies; the processus lateralis forms the most proximal point of the humerus; the capitellum is strong, thick, well modelled, and it extends proximally along the ventral face to reach the plane in which the entepicondylar foramen lies; the twist on the shaft is moderate (10°); the L.M.L. is well developed with a strong swelling on the dorsal surface of the shaft; the A.D.V.L. is strongly developed; the entepicondyle is strongly developed as a thick plate of bone, with the ventral opening of the foramen large and broadly oval, and it is situated far away from the edge of the bone; the ectepicondyle is developed as an outflaring thick sheet of bone pierced obliquely by a small foramen lying well away from the edge of the bone.

The ulna is large and massive (length 402 mm.), wide over the coronoid process (222 mm.); the dorsal rim to the sigmoid face is strong and prominent.

The radius is a large (length 320 mm.) robust bone with a strong proximo-postaxial flange for the biceps.

The manus is unknown.

In the pelvis the supra-acetabular part of the ilium is high (280 mm.) and relatively short (380? mm.), with the height thus 73% of the length; although not fully preserved the anterior iliac process appears to have been fairly short, but fairly high and fairly strongly everted; the posterior iliac process is short, with its postero-ventral edge folded over to form a fairly low and fairly weak oblique ilio-fibularis ridge, which is only slightly thickened in its upper part. The pubes are not preserved and both ischia are incomplete but these appear to have been short.

Both the femur and tibia are too inadequately preserved to merit a description.

The fibula is of moderate robustness and length (294 mm.); the distal end is rather weak and flattened.

The pes is not preserved.

Type: S.A.M. 4343. An imperfect scapula, coracoid and precoracoid (Fig. 75); an imperfect right clavicle (Fig. 76 c-d) and right cleithrum (Fig. 76 a-b); a good right and an imperfect left humerus (Fig. 77); a good left ulna (Fig. 78 a, a¹); the distal end of a radius; an incomplete pelvis (Fig. 79); an imperfect femur; the proximal end of a tibia and a good fibula (Fig. 80), associated with a fairly good skull. Welgemoed, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

Fig. 75.



Scapulo-coracoid of *Jonkeria haughtoni*. S.A.M. 4343. ($\times \frac{1}{8}$)
Lateral view.

Fig. 76.

Jonkeria haughtoni. S.A.M. 4343.
($\times \frac{1}{2}$.) a. Outer view of right
cleithrum. b. Inner view of right
cleithrum. c. Outer view of right
clavicula. d. Inner view of right
clavicula.

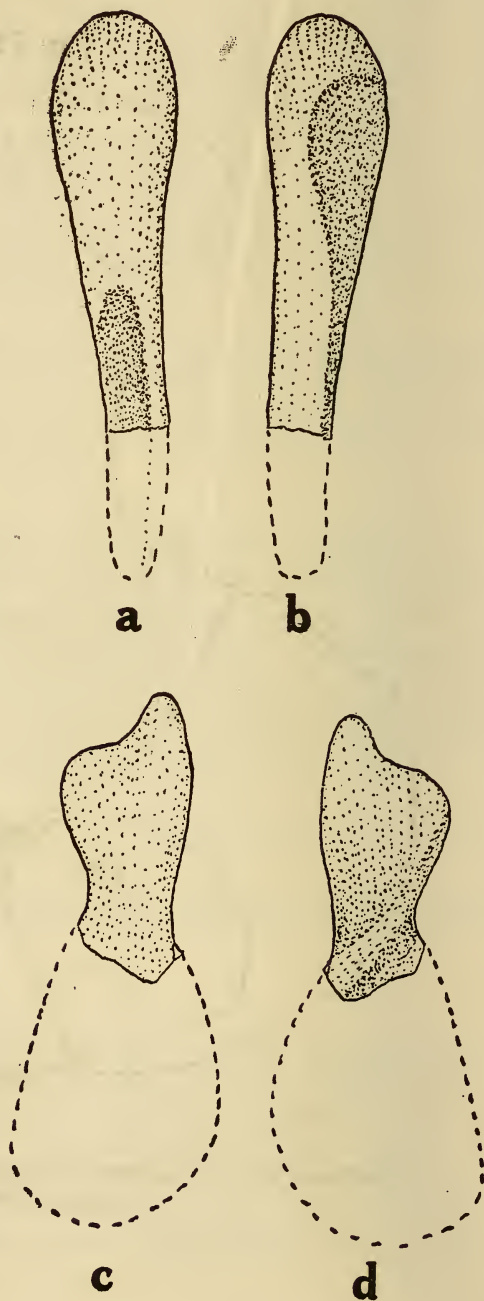
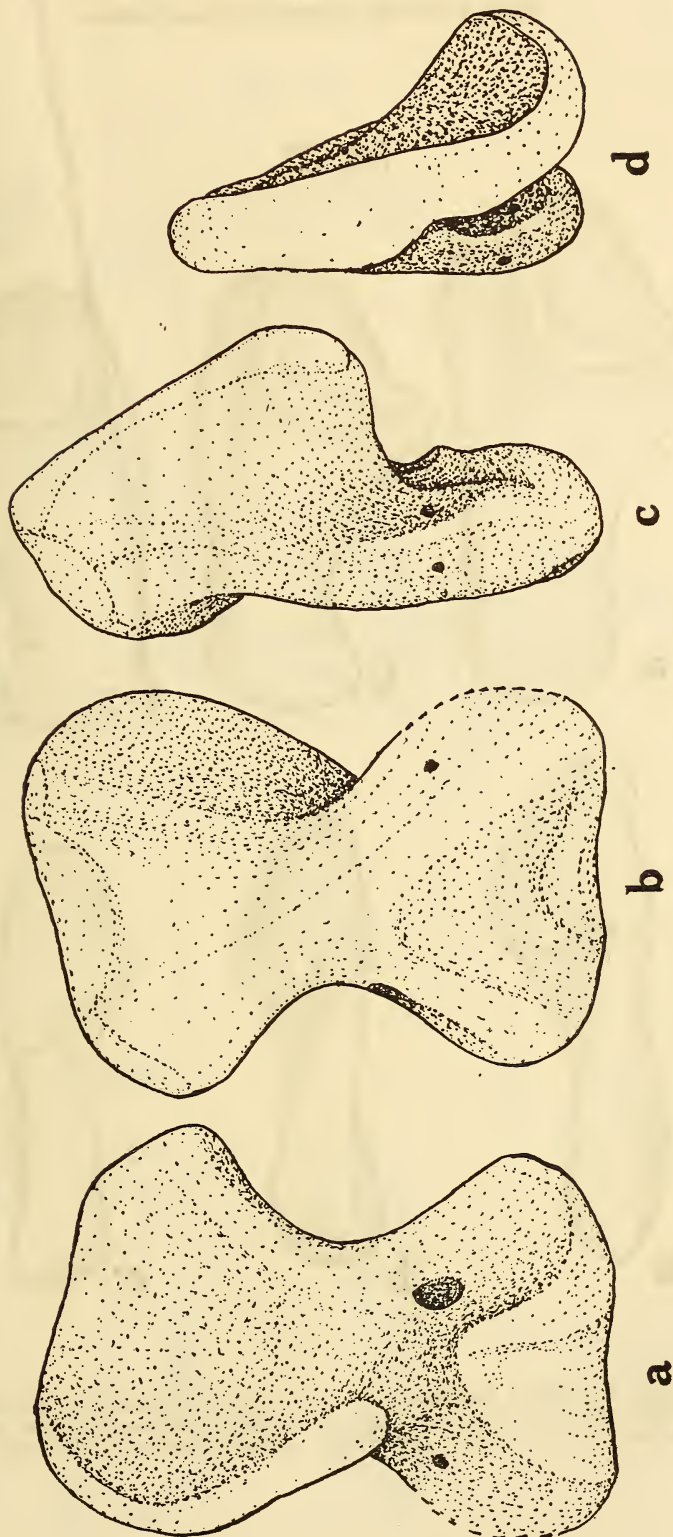
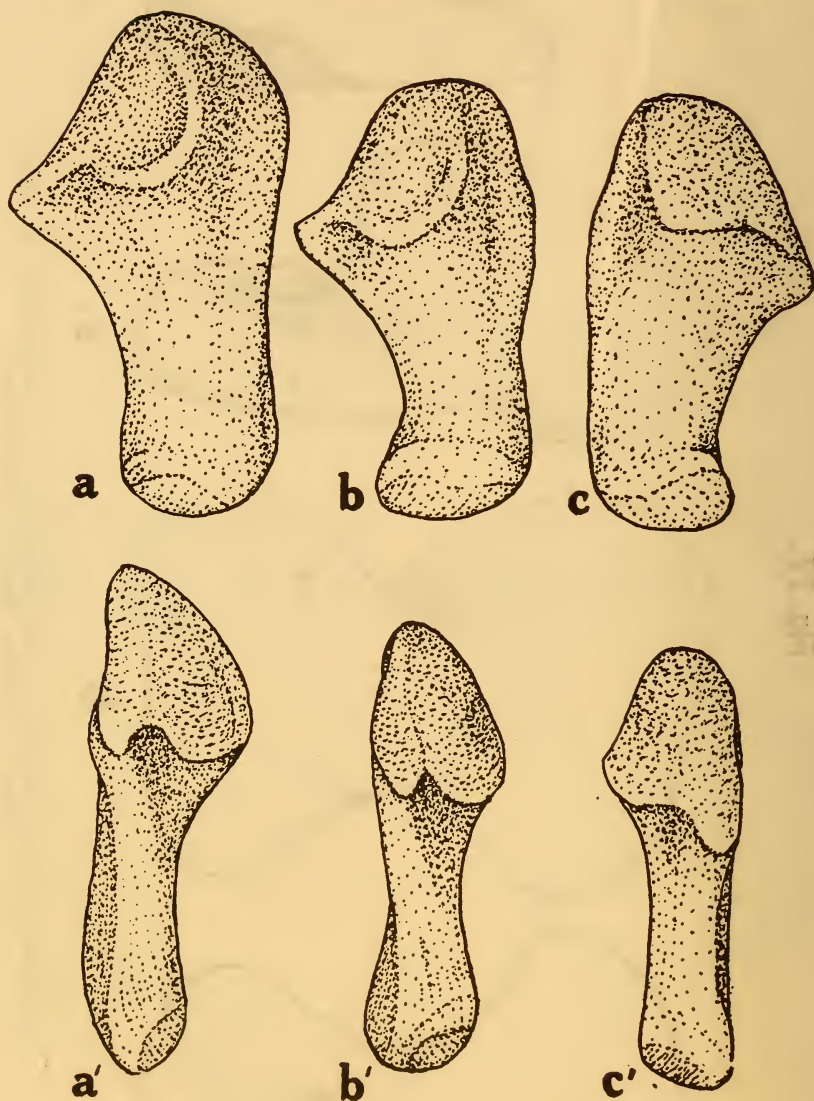


Fig. 77.



Humerus of *Jonkeria laughtoni*. S.A.M. 4343. ($\times \frac{1}{2}$). a. Ventral view. b. Dorsal view. c. Anterior view. d. Proximal view.

Fig. 78.



Ulnae of *Jonkeria haughtoni*. ($\times \frac{1}{6}$.) a and a'. Dorsal and anterior views of S.A.M. 4343. b and b'. Dorsal and anterior views of S.A.M. 11464. c and c'. Dorsal and anterior views of S.A.M. 9002.

Fig. 79.

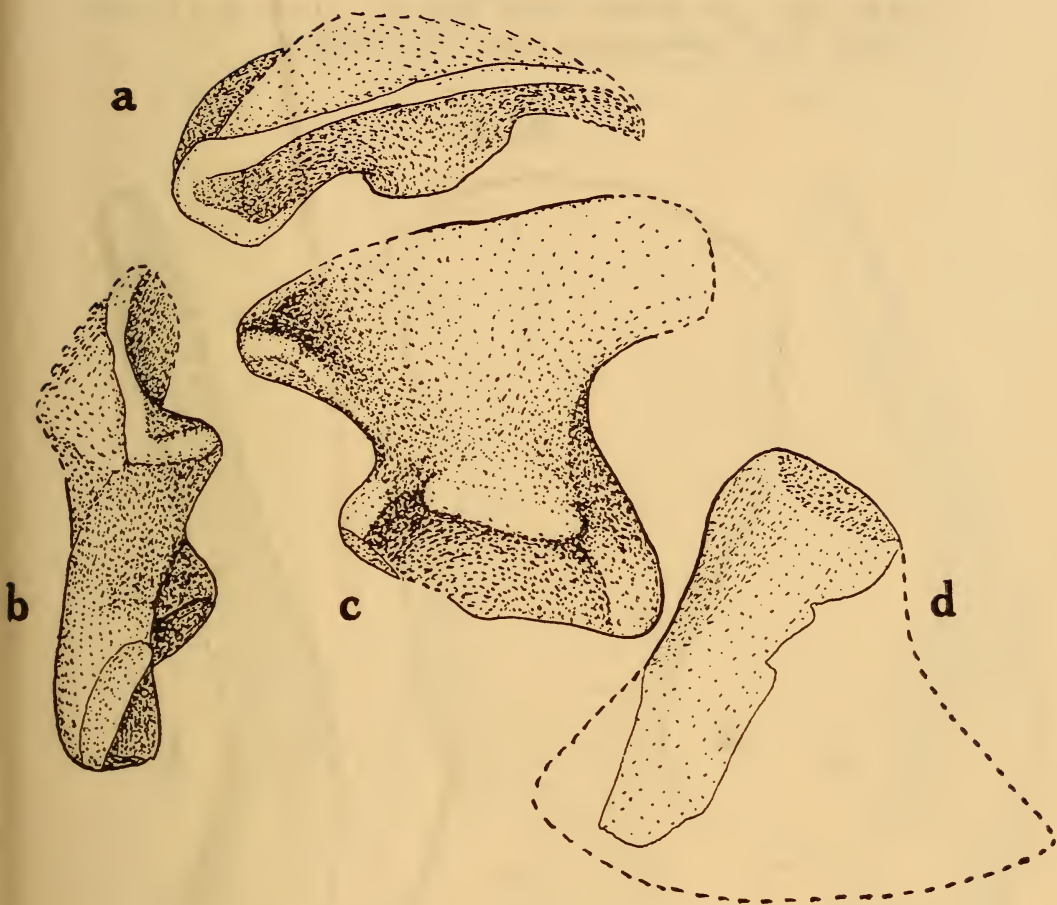
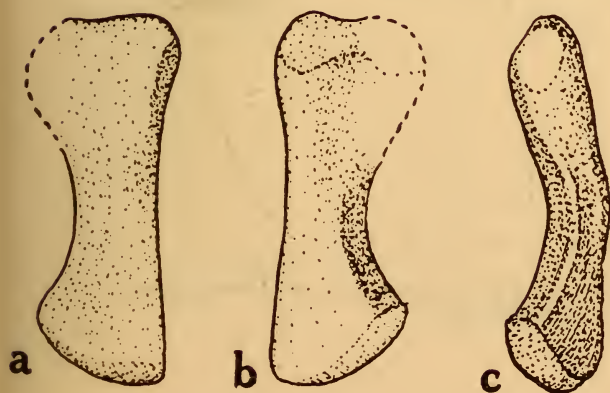


Fig. 80.

Above: *Jonkeria haughtoni*. S.A.M. 4343. ($\times \frac{1}{2}$) a. Ilium in dorsal view. b. Ilium in posterior view. c. Ilium in lateral view. d. Ischium in lateral view.

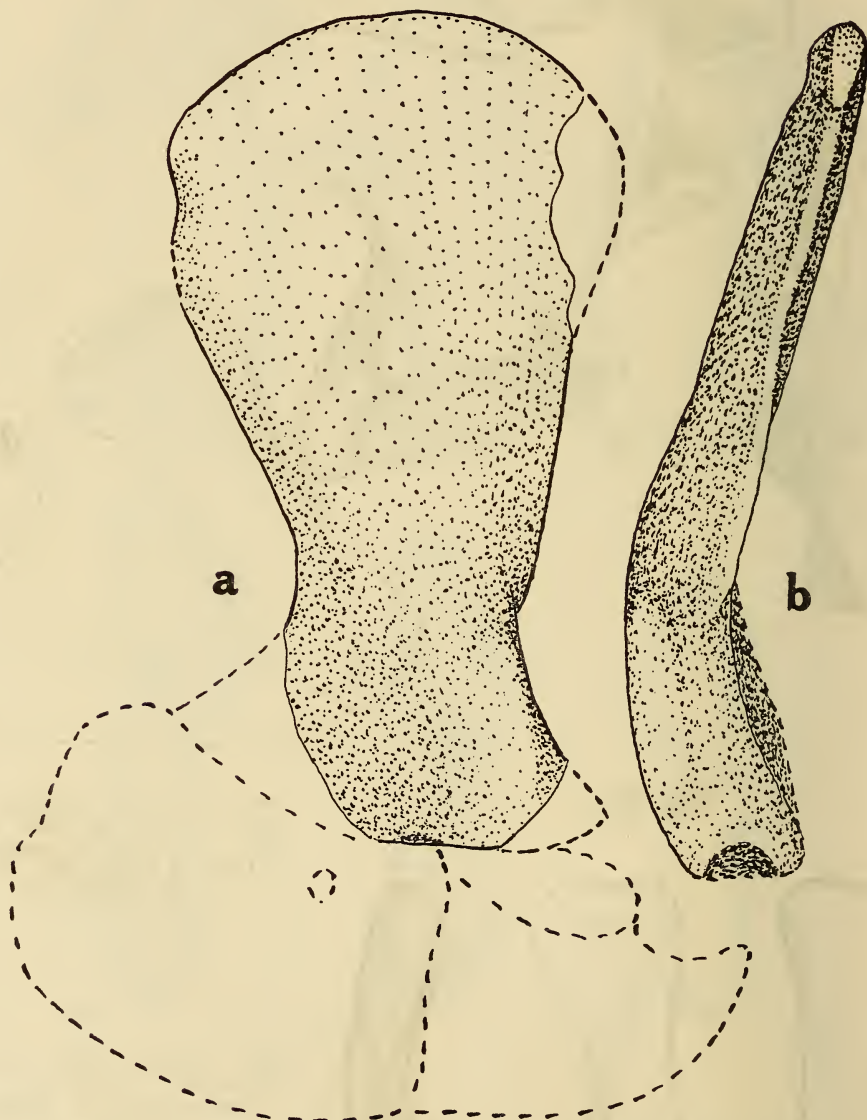


Left: Right fibula of *Jonkeria haughtoni*. S.A.M. 4343. ($\times \frac{1}{2}$) a. Dorsal view. b. Ventral view. c. Anterior view.

Referred specimens in the S.A.M. collection:

S.A.M. 4342. An isolated scapula (Fig. 81). Leeurivier, Beaufort West. Low *Tapinocephalus* zone. Coll. Haughton.

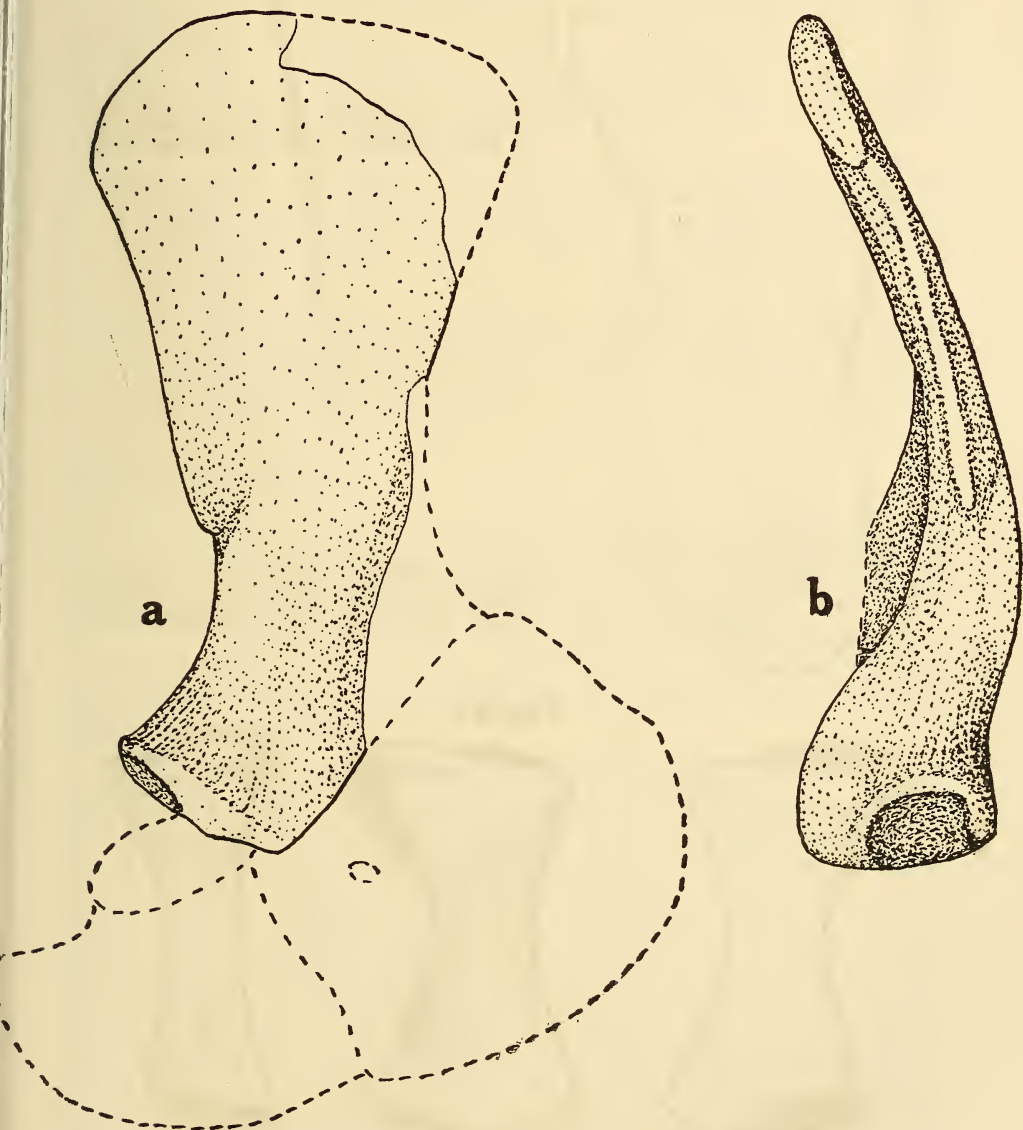
Fig. 81.



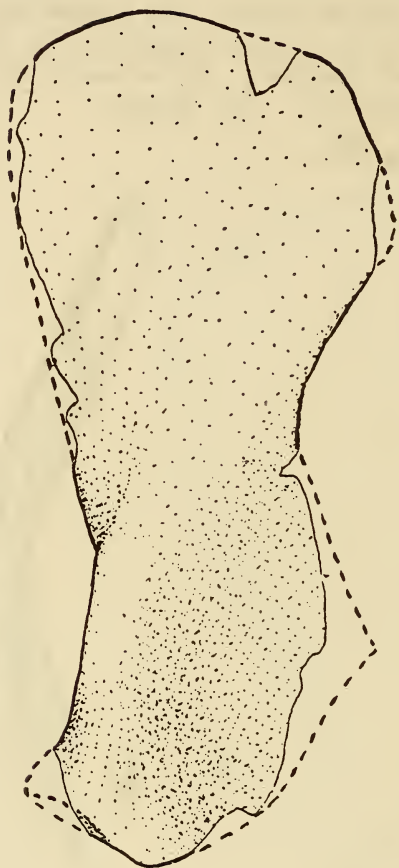
Scapula of *Jonkeria haughtoni*. S.A.M. 4342. ($\times \frac{1}{4}$) a. Lateral view.
b. Posterior view.

S.A.M. 9002. An isolated scapula (Fig. 82) and a distorted ulna (Fig. 78 c, c'). In outline the posterior border of the scapula has a distinctive step also shown in S.A.M. 4342, and probably also in the type where this edge is not preserved. Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 82.

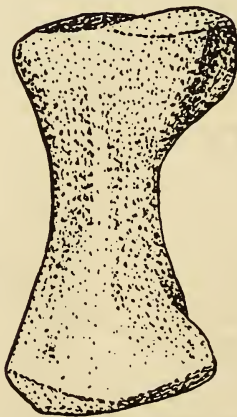
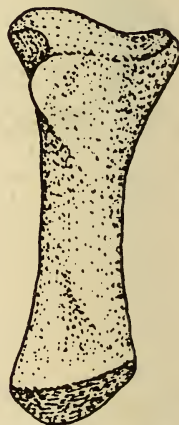


Scapula of *Jonkeria haughtoni*. S.A.M. 9002. ($\times \frac{1}{4}$) a. Lateral view.
b. Posterior view.

Fig. 83.

Left: Scapula of *Jonkeria haughtoni*.
S.A.M. 11297. ($\times \frac{1}{8}$) Lateral view.

Below: Right radius of *Jonkeria haughtoni*, S.A.M. 9145. ($\times \frac{1}{8}$) a. Dorsal view. b. Ventral view. c. Posterior view.

Fig. 84.**a****b****c**

- S.A.M. 11297. An isolated scapula (Fig. 83). Boesmansrivier, Beaufort West. Mid *Tapinocephalus* zone. Coll. Boonstra.
- S.A.M. 9009. An isolated precoracoid. This medium-sized bone, composed of a thin sheet except at the apex, where the sutural faces for the coracoid and scapula are fairly strong, is very similar to that of *J. truculenta* but larger, and is probably that of *J. haughtoni*. Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.
- S.A.M. 9145. A good radius (Fig. 84) and an incomplete pubis probably belong to this species. Seekoeivlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.
- S.A.M. 9147. An isolated ulna with a damaged proximal end agrees sufficiently well with that of the type to be included in this species. Seekoeivlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.
- S.A.M. 11464. A very well preserved ulna (Fig. 78 b, b'); although somewhat shorter than that of the type it can safely be included in this species. Koedoeskop, Beaufort West. Mid *Tapinocephalus* zone. Coll. Boonstra and Avenant.

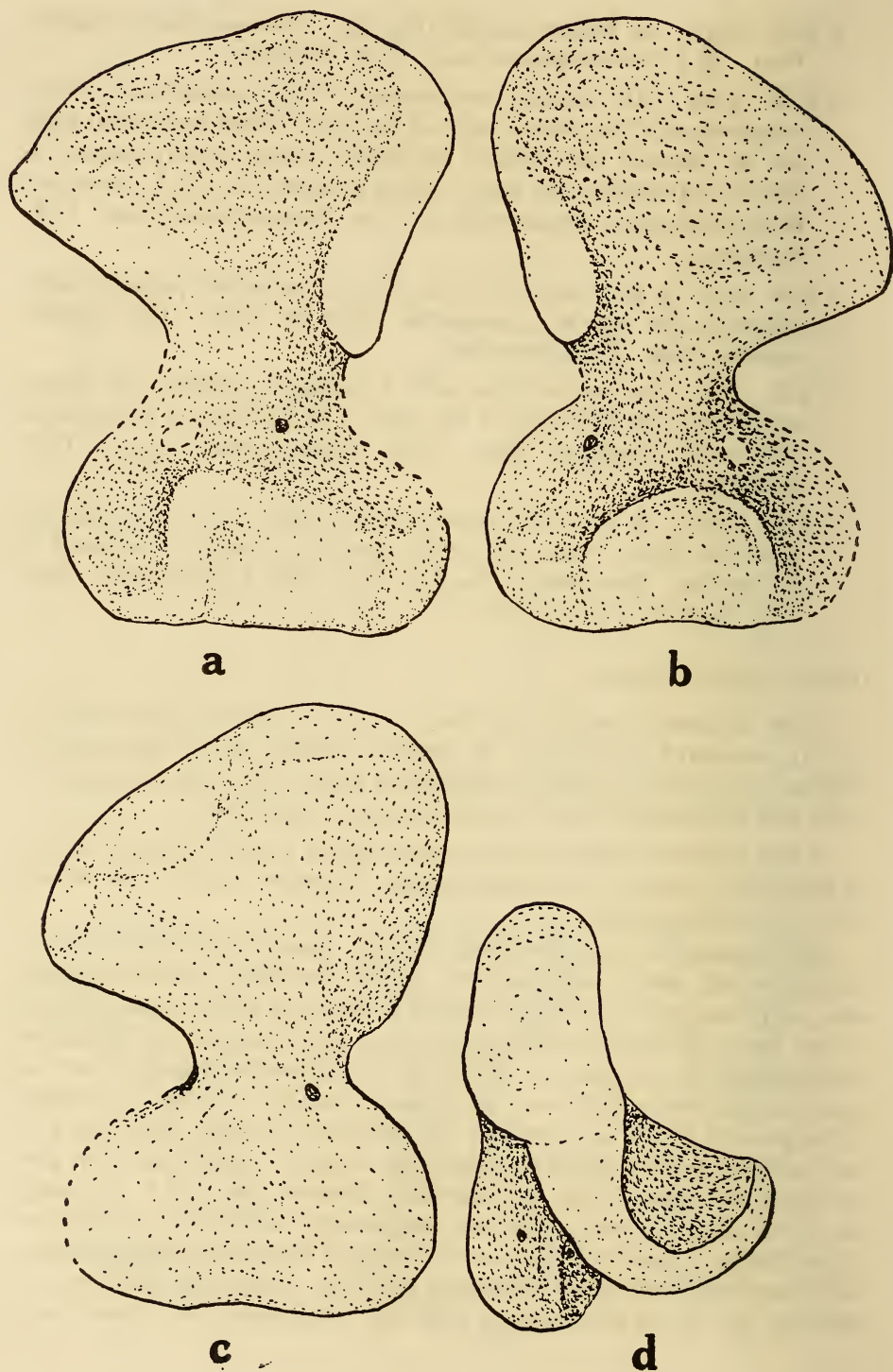
Jonkeria ingens (Broom)

In the specimen described by Broom (14) as *Jonkeria pugnax* but by me (1) considered a synonym of *Jonkeria ingens* Broom mentions the scapulae but without figuring or describing them; and of the humerus he states that it resembles that of *Jonkeria crassus* very closely.

In this collection there are four humeri, which in point of size can best be tentatively referred to this large species of *Jonkeria*, rather than to any other of the Titanosuchids.

The humerus in these specimens is large, massive, but not very long (length 504-510 mm.); both ends are greatly expanded (proximal 330-336 mm., and distal 312?-324 mm.); the shaft is short and broad (diams. 130-156 × 110 mm.); the delto-pectoral crest is long and powerful, but terminates well proximal of the plane in which the entepicondylar foramen lies; the caput is large and widely oval; the processus medialis lies very far distally of the plane in which the caput lies; the capitellum is strong, thick and very well modelled and it extends far proximally along the ventral face, but does not reach the plane of the entepicondylar foramen; the L.M.L. is strong; the A.D.V.L. is not very sharp; the entepicondyle is strongly developed as a thick flange of bone, with the ventral opening of the entepicondylar foramen fairly large and oval, lying fairly near the edge of the bone well removed from the base of the delto-pectoral crest; the ectepicondyle is a flaring sheet

Fig. 85.



Humeri of *Jonkeria ?ingens*. ($\times \frac{1}{2}$.) a. S.A.M. 3433. Ventral view. b. S.A.M. 738. Ventral view. c. S.A.M. 738. Dorsal view. d. S.A.M. 738. Proximal view.

of bone pierced vertically by the small foramen lying well away from the edge of the bone.

Referred specimens:

A.M.N.H. 5608. Much of two scapulae and a humerus, associated with a skull. Kookfontein, Prince Albert. Mid *Tapinocephalus* zone. Coll. van Wyk.

S.A.M. 738. A good isolated humerus (Fig. 85 b-d). Gamka River. Low? *Tapinocephalus* zone. Coll. Cloete.

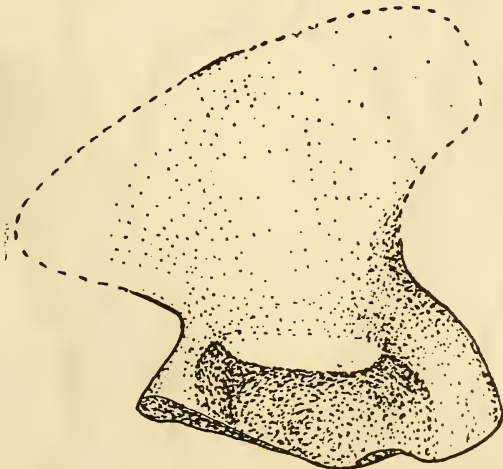
S.A.M. 3433. A good isolated humerus (Fig. 85a). Janwillemsfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

S.A.M. 9006. An isolated proximal half of a humerus. Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

S.A.M. 11994. An incomplete isolated humerus with a good distal end. Welgemoed, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

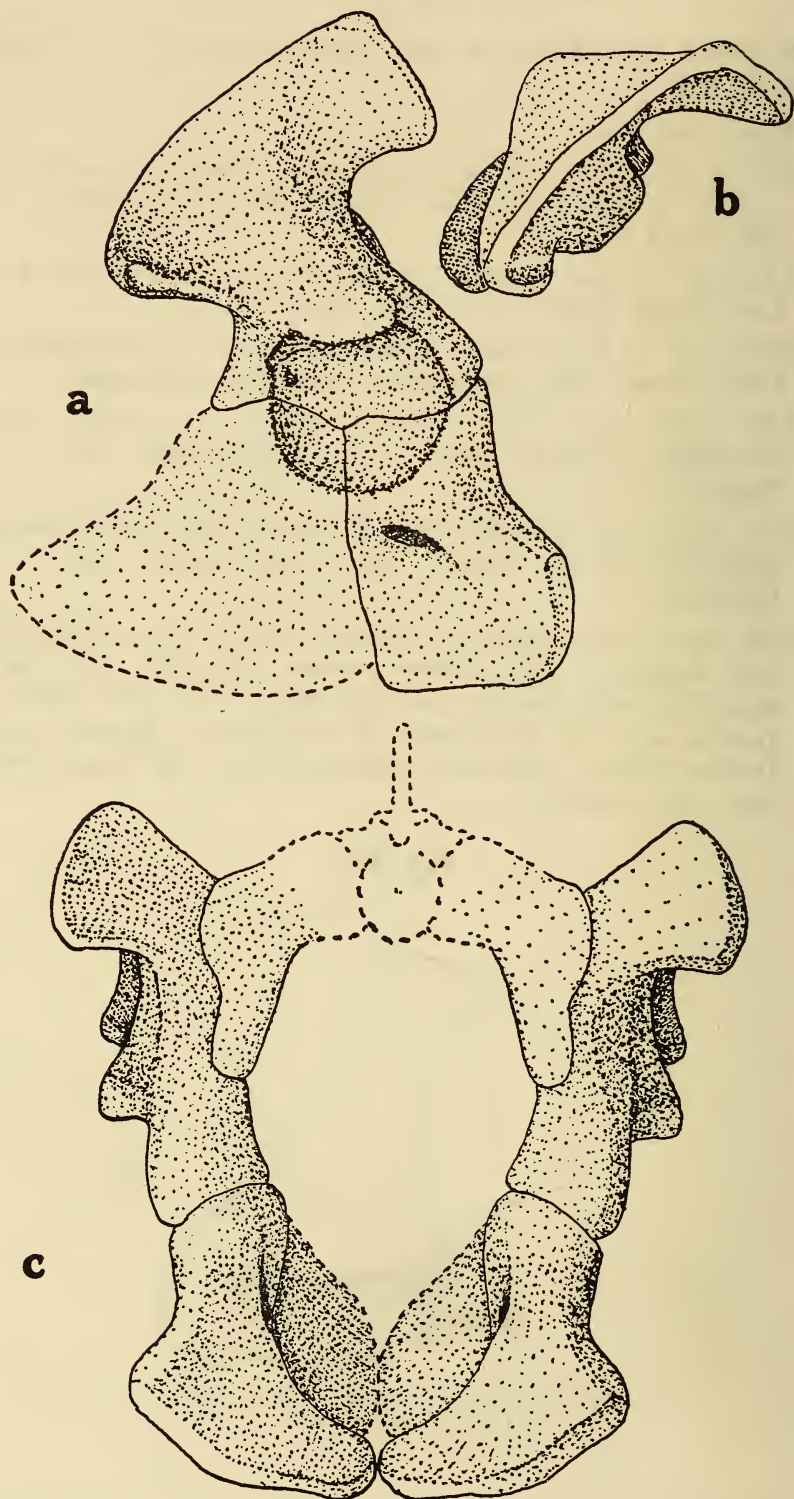
S.A.M. 9348. An incomplete and distorted humerus and an ilium lacking both the anterior and posterior processes (Fig. 86). The ilium is larger and more strongly built than those of the other species of *Jonkeria* and may provisionally be considered to represent that of *Jonkeria ingens*. Mierfontein, Beaufort West. Mid *Tapinocephalus* zone. Coll. Boonstra.

Fig. 86.



Ilium of *Jonkeria ?ingens*. S.A.M. 9348.
($\times \frac{1}{4}$.) Lateral view.

Fig. 87.



Jonkeria koupensis. S.A.M. 9004. ($\times \frac{1}{6}$.) a. Pelvis in lateral view.
b. Ilium in dorsal view. c. Pelvis in anterior view.

Jonkeria koupensis Sp. Nov.

This new species appears to be very closely related to *J. haughtoni*, but the differences in the pelvis, as will be evident from the accompanying characterisation, warrant treatment as a distinct form.

In the pelvis the pubo-ischiadic plate is probably short (83% of the height as reconstructed); the supra-acetabular part of the ilium is high (264 mm.) and the antero-posterior length of the iliac blade is very short (282 mm.), so that the height is 93% of the length; the anterior iliac process is fairly short, but appears shorter than it really is because of its strong eversion antero-laterally, and is fairly high; the posterior process is short and fairly low, with its postero-ventral edge moderately strongly folded over to form a fairly strong ilio-fibularis ridge on the outer face; this ridge is directed obliquely upwards, with its upper end not strongly bulbously thickened; a slight groove on the inner face of the everted anterior iliac process indicates the attachment of a rib anterior to the main sacral rib; antero-posteriorly the outer face of the iliac blade is deeply concave.

The antero-ventral edge of the pubis is strongly everted, with the tuberculum pubis confluent with the thickened part of the antero-ventral edge, which stretches to the median line where the pubes meet, but do not form a real symphysis.

The ischium is not preserved but probably is as reconstructed.

The ulna has the distal two-thirds preserved; it is a massive bone with the dorsal lip of the sigmoid face developed into a massive swelling in its preaxial part.

Fig. 88.



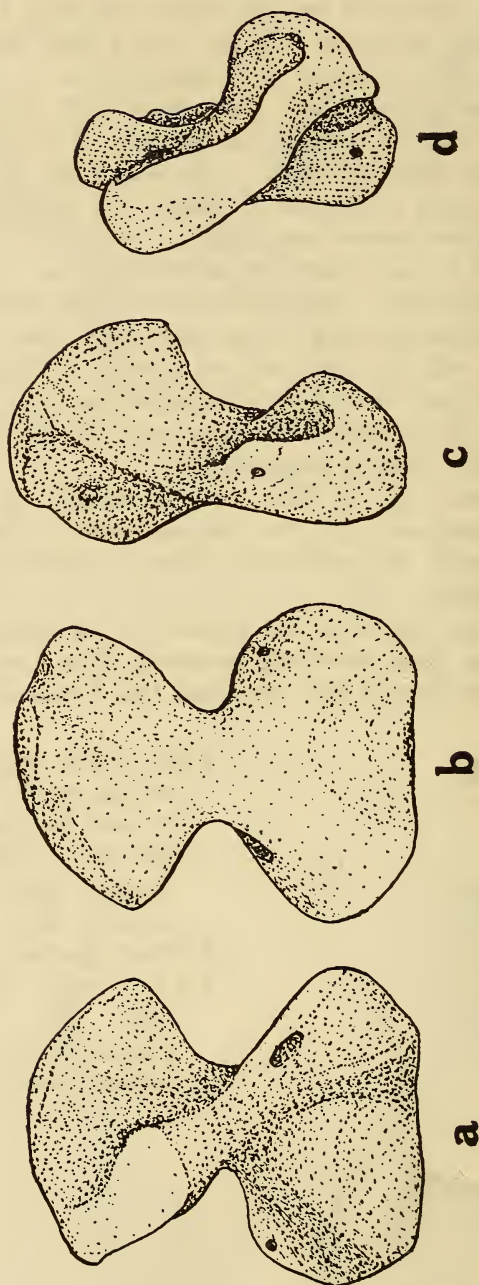
Type: S.A.M. 9004. A good pelvis, lacking only the ischia (Fig. 87) and the distal two-thirds of the ulna. Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Referred specimen:

S.A.M. 11983. An isolated ilium (Fig. 88). Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

Ilium of *Jonkeria koupensis*. S.A.M. 11983. ($\times \frac{1}{2}$.) Lateral view.

Fig. 89.



Humerus of *Jonkeria parva*. S.A.M. 9149. ($\times \frac{1}{2}$.) a. Ventral view. b. Dorsal view.
c. Anterior view. d. Proximal view.

Jonkeria parva Sp. Nov.

Although only a single isolated humerus is known, this bone is so distinctive that I do not hesitate to make it the type of a new species of *Jonkeria*.

This humerus is the smallest *Jonkeria* humerus as yet known; its length is only 312 mm., but it is a very massive element with both the proximal (222 mm.) and the distal (252 mm.) ends very greatly expanded; the shaft is very short and the bone is greatly constricted in the waist; the diameters of the shaft are 84×78 mm.; the delto-pectoral crest is fairly short and it terminates very far proximal of the plane in which the entepicondylar foramen lies; it has a very massive ventral edge and it terminates as a very thick knob. The caput is weak and its face is straplike, but it forms the most proximal part of the bone; the processus lateralis lies more distal than the caput; the processus medialis, as in all the *Jonkerias*, lies well distally of the caput; the capitellum is very massive indeed and it extends very far proximally along the ventral face, with its proximal border lying in a plane proximal to that in which the entepicondylar foramen lies; posteriorly of the well-modelled capitellum there is a deep groove in which the coronoid process moved when the ulna was flexed; the twist on the shaft is great (30°); the L.M.L. is distinct, with a large moundlike muscle scar on the dorsal surface of the shaft; the A.D.V.L. is very strong and forms a prominent ridge; the entepicondyle is strongly developed to form a greatly outflaring thick sheet of bone; the ventral opening of the entepicondylar foramen is oval and it lies well postaxially, near the edge of the bone; the ectepicondyle is developed as a greatly flaring thin sheet of bone penetrated in its thinner part, near the edge, by a small round ectepicondylar foramen.

Type: S.A.M. 9149. An isolated right humerus very well preserved (Fig. 89). Saairivier, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

Jonkeria rossouwii Sp. Nov.

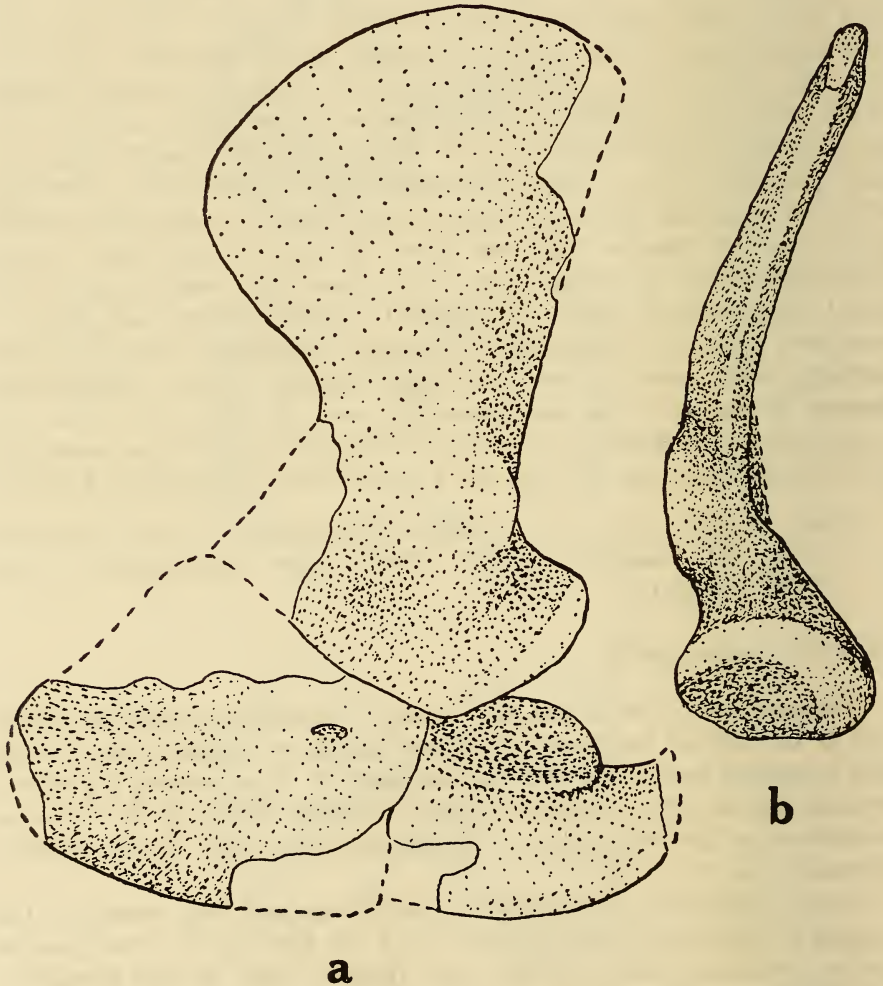
The specimen on which this new species is founded was found by Broom (14) to be different from the then known species of *Jonkeria*, but Broom, with a restraint unusual for him, did not name it. I am naming it *Jonkeria rossouwii* for Mr. P. J. Rossouw of the Geological Survey of the Union in recognition of the importance of his stratigraphical work on the *Tapinocephalus* zone.

In this species the pectoral girdle is fairly large and fairly massive. The scapula is fairly low (height 552 mm.) and the upper part of the blade is greatly expanded (width 324 mm.); the tricipital bulge is very prominent; the supra-glenoidal edge forms a strong raised rim; the internal opening of

the supracoracoid foramen opens into the deep subscapular groove; the glenoidal facet of the scapula faces ventro-posteriorly but not externally. The precoracoid is long but low (somewhat affected by crushing); the foramen pierces the bone very obliquely. The coracoid is small but massive, with a large glenoidal facet facing well externally.

The interclavicle is massive but short (480? mm.) with the stem wide posteriorly and with a narrowed waist anteriorly; the anterior spatulate end curves upwards very sharply and has a deep groove on its outer antero-

Fig. 90.



Jonkeria rossouwi. S.A.M. 5014. ($\times \frac{1}{4}$.) a. Scapulo-coracoid in lateral view
b. Scapula in posterior view.

lateral face for the reception of the postero-ventral edge of the clavicle; on the dorsal surface of the stem there is a strong medial ridge against which the precoracoids abut.

The clavicles and cleithrum are not known.

The humerus is fairly short (378 mm. in length), but massive with greatly expanded proximal (330 mm.) and distal (276? mm.) ends; the shaft is very short, thick and broad (132×84 mm.); the delto-pectoral crest is very long and nearly reaches the plane in which the entepicondylar foramen lies; the caput is broadly oval; the processus lateralis lies well proximally, in the same plane as the caput, whereas the processus medialis lies well distally; the capitellum is fairly massive and extends well along the ventral face and nearly reaches the plane of the entepicondylar foramen; the "twist" on the shaft is fairly small (15°); the L.M.L. is fairly strong with muscle scars on the dorsal surface of the shaft; the A.D.V.L. is well developed; the entepicondyle is strong with the ventral opening of the foramen large and nearly round; the ectepicondyle forms a thick flange pierced by the small foramen situated well away from the edge of the bone.

(The dorsal surface of the ectepicondyle shows a pathological lesion in the form of an irregular deep excavation and this is accompanied by a concomitant outgrowth of the olecranon of the ulna. In another humerus, that of *Phocosaurus* S.A.M. 11300, the disto-ventral face of the capitellum is deeply eroded with subsequent healing and the formation of a new but concave instead of a convex articular facet. (Osteitis fibrosa? Osteomalachia?))

The ulna has suffered pathological deformation so that the olecranon is proximally prolonged as a thick outgrowth. The normal ulna would appear to have had a more slender shaft and a weaker coronoid process than the other known species of *Jonkeria*.

The radius is only slightly pathologically deformed. Its length is 312 mm. and the flange on the proximo-postaxial corner is weak.

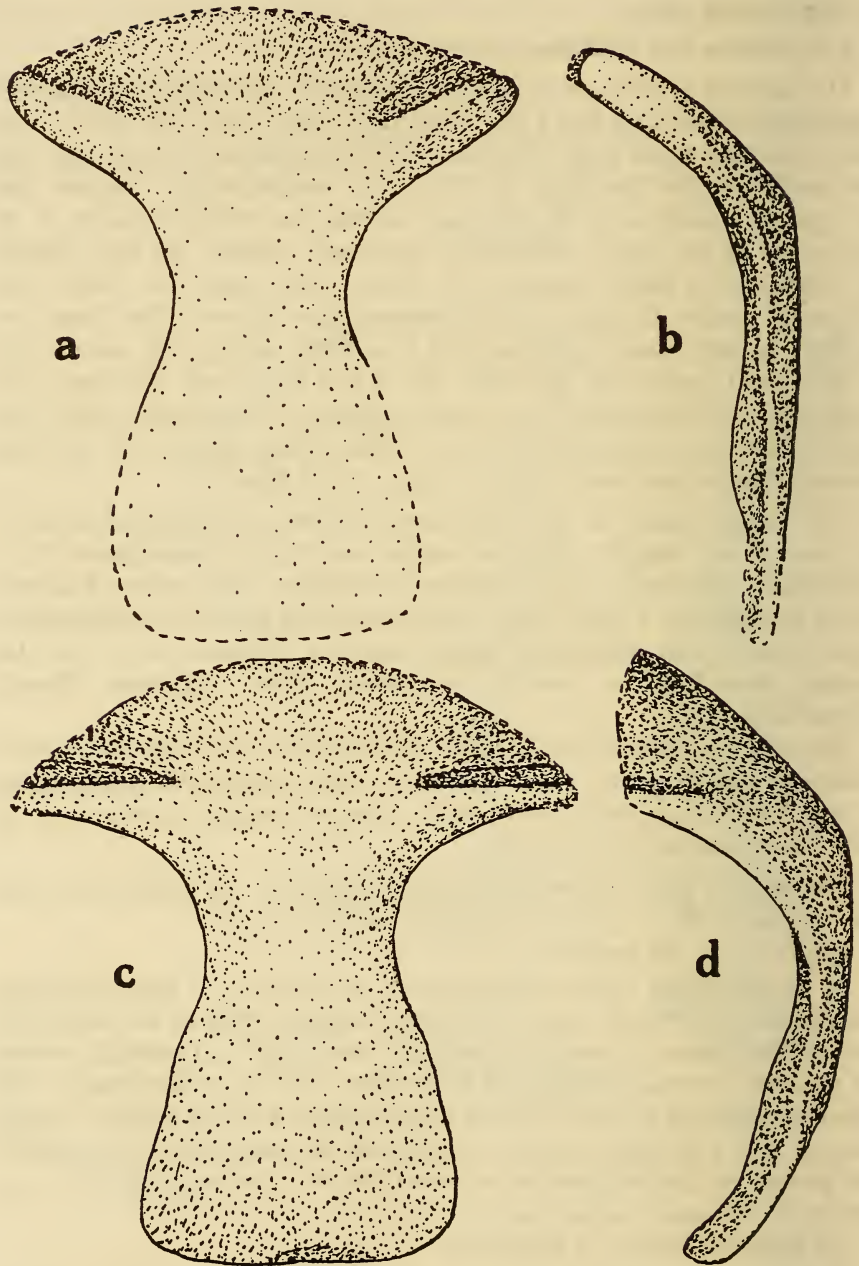
The manus is not known.

In the pelvis the supra-acetabular part of the ilium is high (288 mm.) and relatively short (336 mm.) so that the height is 87% of the length; the anterior iliac process is relatively short, but fairly high and strongly everted; the posterior process is short and fairly low, with its postero-ventral edge folded over strongly to form a strong vertical ridge, which is dorsally strongly bulbous, and it projects strongly laterally; on the inner face of the anterior iliac process no distinct facet is preserved for the attachment of a rib lying anterior to the main sacral rib.

No pubis or ischium is preserved.

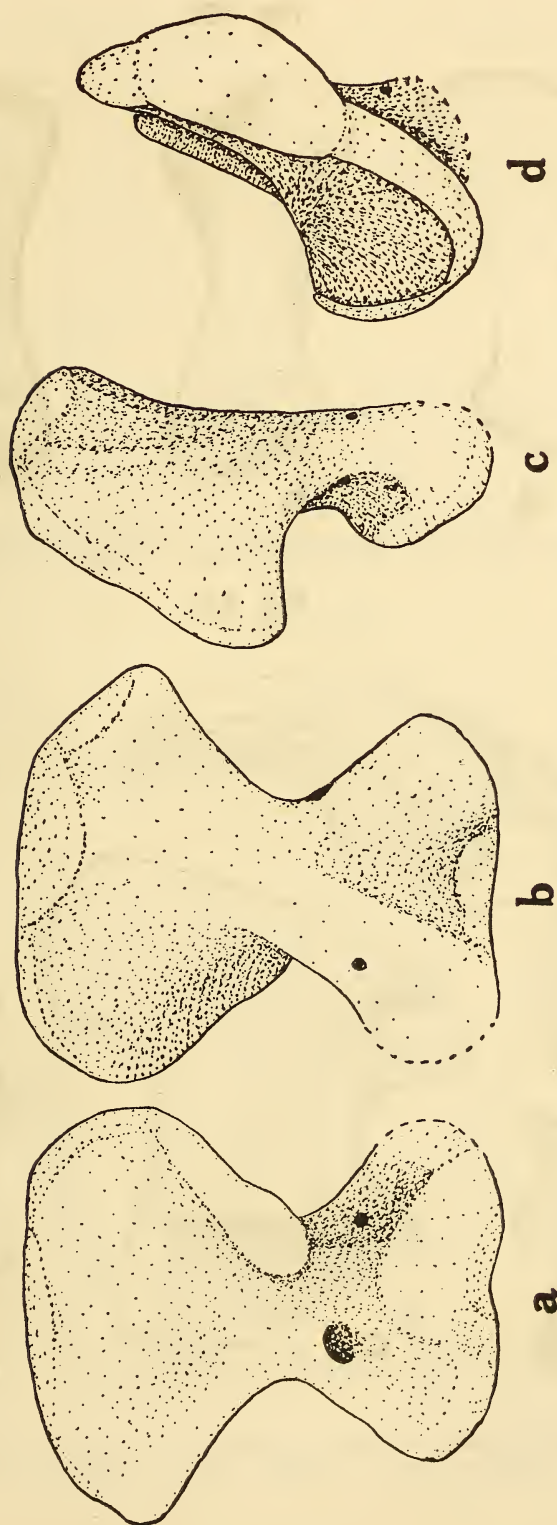
The femur is fairly long (504 mm.); fairly broad over the external trochanter (264 mm.), which is not separated by a notch from the proximal

Fig. 91.



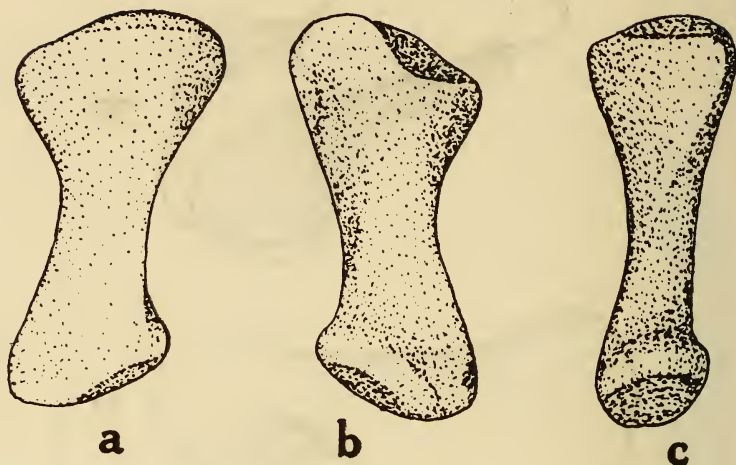
Interclaviculae. ($\times \frac{1}{8}$.) a. *Jonkeria rossouwi*. S.A.M. 5014. Ventral view.
 b. *Jonkeria rossouwi*. S.A.M. 5014. Lateral view. c. *Jonkeria* sp. indet.
 S.A.M. 9124. Ventral view. d. *Jonkeria* sp. indet. S.A.M. 9124. Lateral view.

Fig. 92.



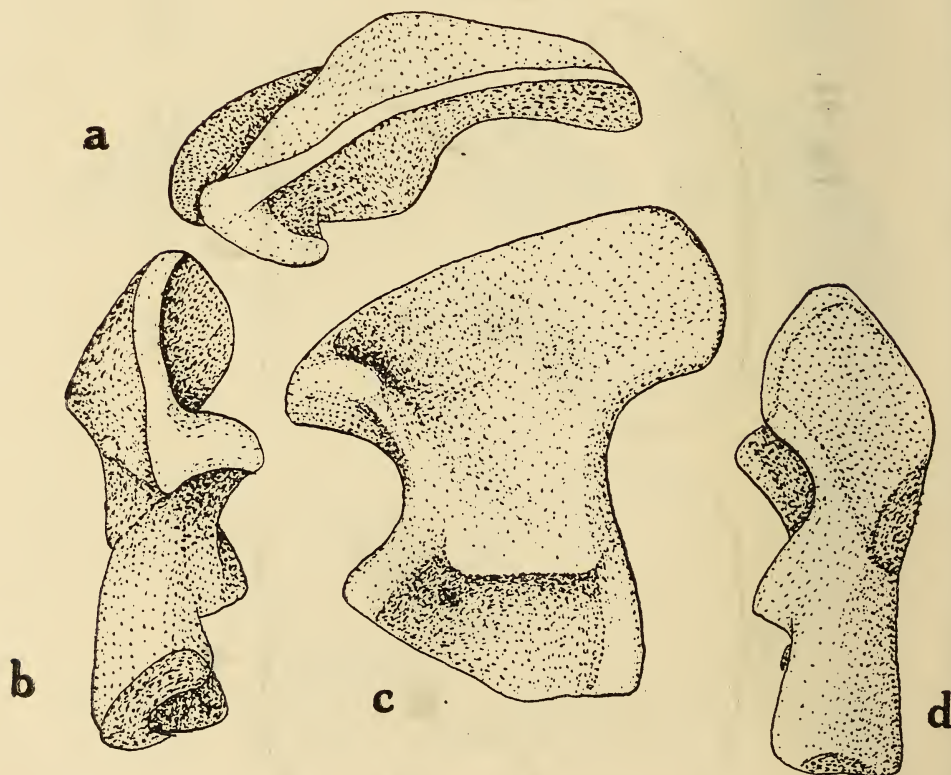
Humerus of *Jonkeria rossouwi*. S.A.M. 5014. ($\times \frac{1}{2}$) a. Ventral view. b. Dorsal view. c. Anterior view. d. Proximal view.

Fig. 93.



Left radius of *Jonkeria rossouwi*. S.A.M. 5014. ($\times \frac{1}{6}$.)
 a. Dorsal view. b. Ventral view. c. Posterior view.

Fig. 94.



Right ilium of *Jonkeria rossouwi*. S.A.M. 5014. ($\times \frac{1}{6}$.) a. Dorsal view.
 b. Posterior view. c. Lateral view. d. Anterior view.

face; the caput is fairly thick (114 mm.) and is directed much preaxially; the shaft is broad but flat (diams. 156×84 mm.); the femoro-tibialis ridge is fairly strong; the distal facets of the femur are small and directed much distally, especially the ectepicondyle which lies far distally. (These features of the distal end of the femur, differing as they do from the other *Jonkerias*, appear to be due to some measure of pathological deformation.)

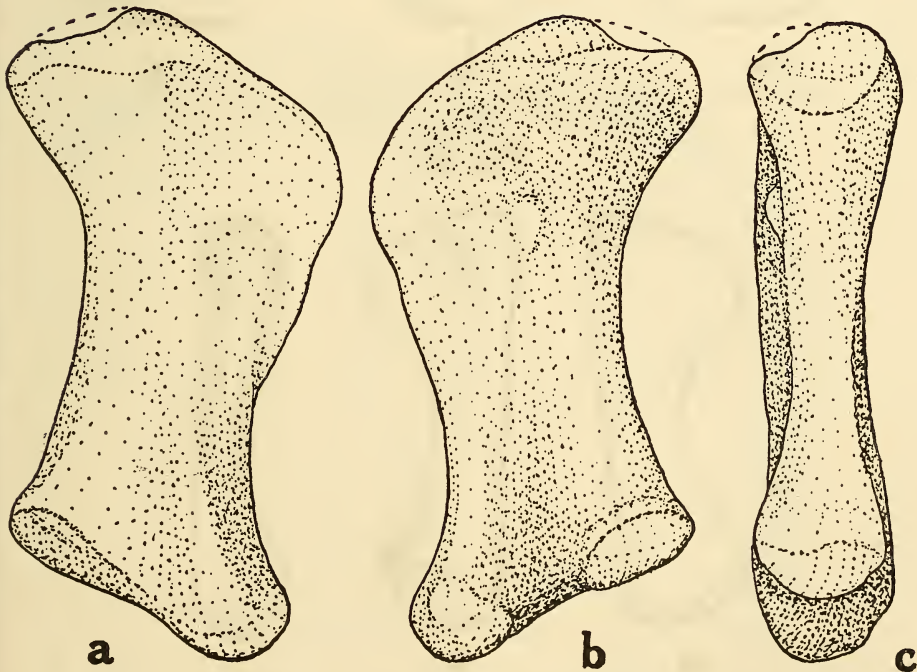
The tibia is fairly robust (length 300 mm.); the proximal face is inclined much postaxially to correspond with the distally situated postaxial facet of the femur.

The fibula is fairly slender and long (330 mm.).

The pes is not known.

Type: S.A.M. 5014. The left scapula and incomplete precoracoid and coracoid (Fig. 90), an imperfect interclavicle (Fig. 91 a, b), a diseased left humerus (Fig. 92), a deformed left ulna and a left radius (Fig. 93), a right ilium (Fig. 94), a left femur (Fig. 95), a left tibia (Fig. 96) and a left fibula (Fig. 97). Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. van der Byl.

Fig. 95.



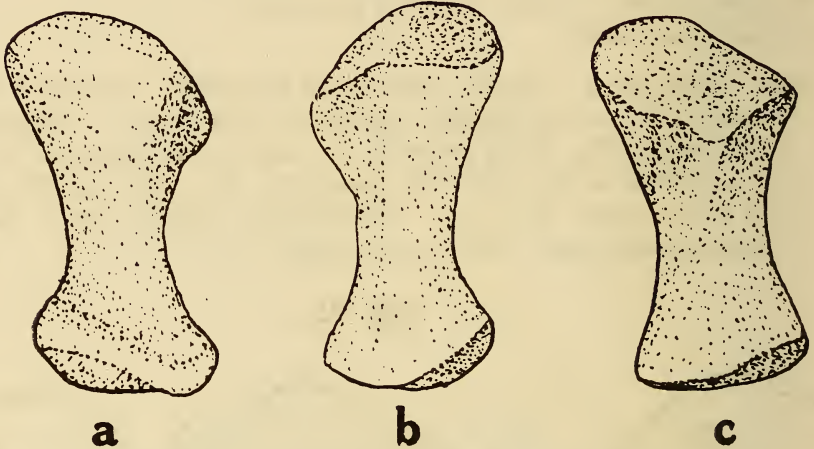
Left femur of *Jonkeria rossouwii*. S.A.M. 5014. ($\times \frac{1}{8}$.) a. Dorsal view. b. Ventral view. c. Anterior view.

Referred specimens:

S.A.M. 11979. An incomplete interclavicle (Fig. 98 a, b) and the proximal ends of an ulna and fibula. Kruisvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

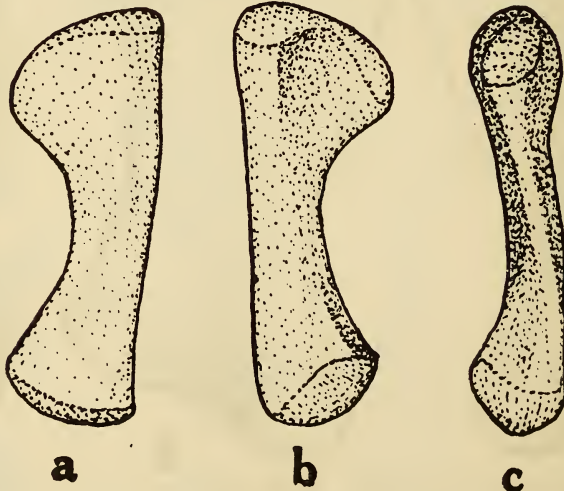
S.A.M. 11982. A fairly good interclavicle (Fig. 98 c, d). Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

Fig. 96.



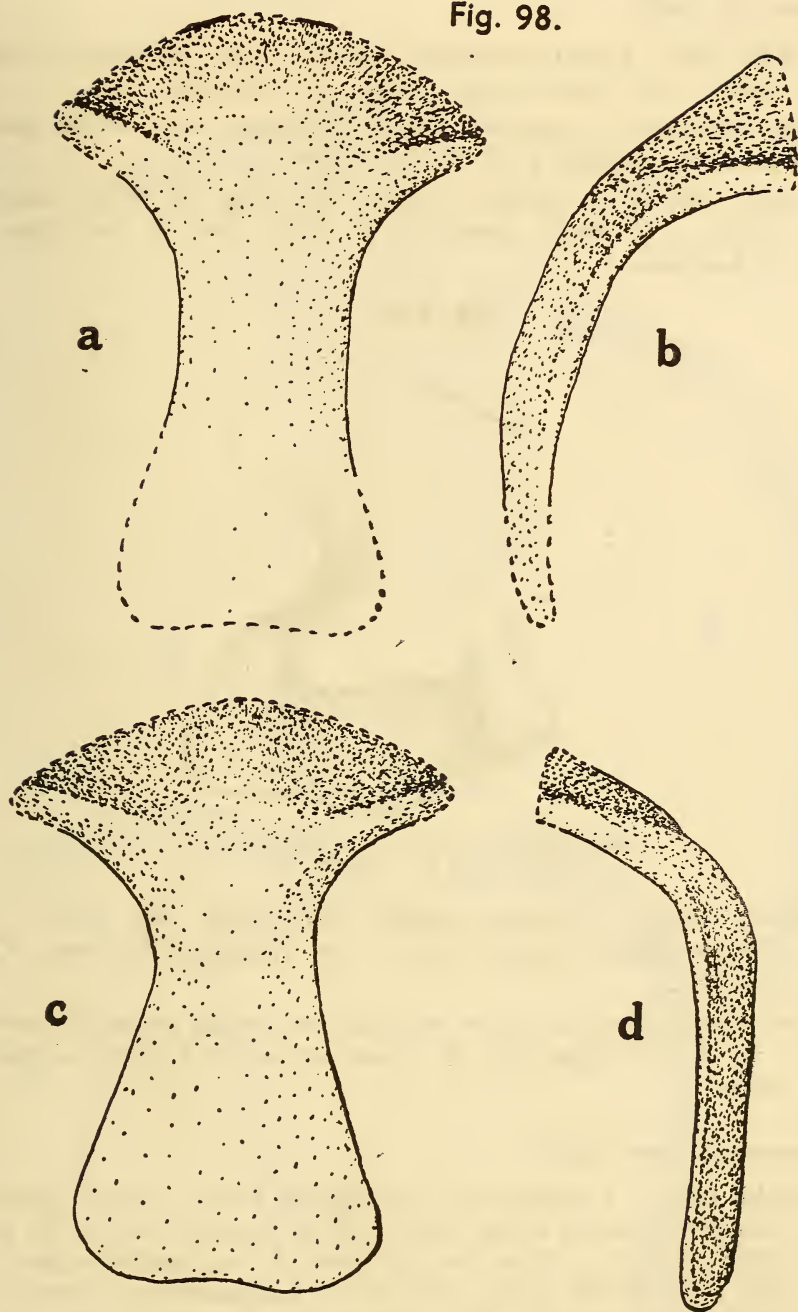
Left tibia of *Jonkeria rossouwi*. S.A.M. 5014. ($\times \frac{1}{8}$.) a. Dorsal view. b. Ventral view. c. Posterior view.

Fig. 97.



Left fibula of *Jonkeria rossouwi*. S.A.M. 5014. ($\times \frac{1}{8}$.) a. Dorsal view. b. Ventral view. c. Anterior view.

Fig. 98.



Interclavicularae of *Jonkeria rossouwi*. ($\times \frac{1}{2}$.) a. S.A.M. 11979. Ventral view. b. S.A.M. 11979. Lateral view. c. S.A.M. 11982. Ventral view. d. S.A.M. 11982. Lateral view.

Jonkeria Sp. Indet.

S.A.M. 9124. A good interclavicle (Fig. 91, c, d). Voëlfontein, Prince Albert. Low *Tapinocephalus* zone. Coll. Boonstra.

This interclavicle is larger and stronger than those of the known species of *Jonkeria* and may thus possibly be *J. ingens*.

S.A.M. 11984. An imperfect isolated ilium (Fig. 99) of an unknown locality. It would appear to lie fairly close to the ilium of *J. haughtoni*.

Fig. 99.



Right ilium of *Jonkeria* sp. indet. S.A.M. 11984. ($\times \frac{1}{6}$) Lateral view.

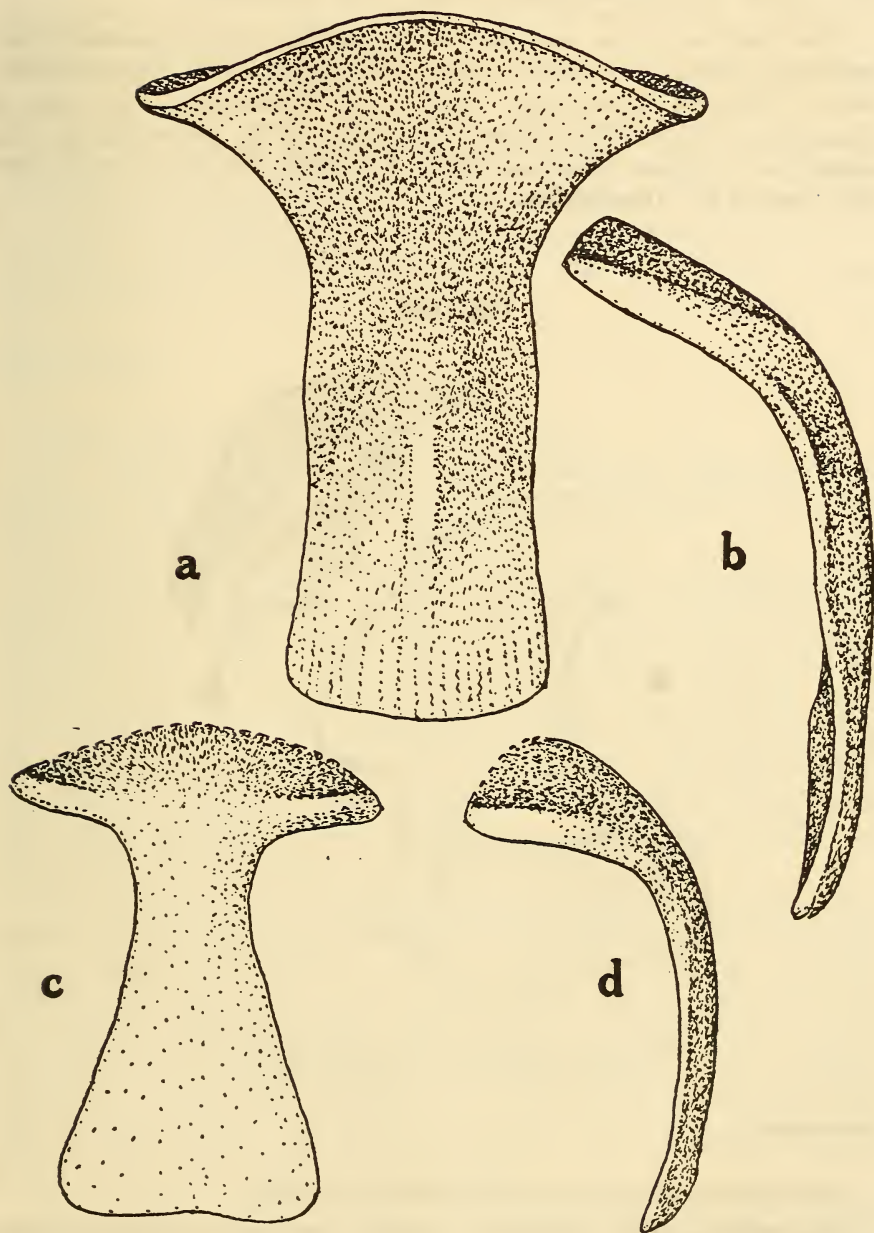
S.A.M. 11886. A nearly complete interclavicle (Fig. 100 c, d). Vindraersfontein, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

This small bone with a narrow waist and the strongly expanded posterior end of the stem is apparently of a small species of *Jonkeria* — possibly of *J. parva*.

Titanosuchia Genera Indet.

S.A.M. 11571. A large isolated interclavicle with a strongly upturned anterior end and a strong median keel on the dorsal face of the stem (Fig. 100 a, b). It has the long stem of the *Tapinocephalians* but the width is that usually seen in the *Titanosuchians*. Probably a large *Titanosuchid*. Klein-Koedoeskop, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 100.

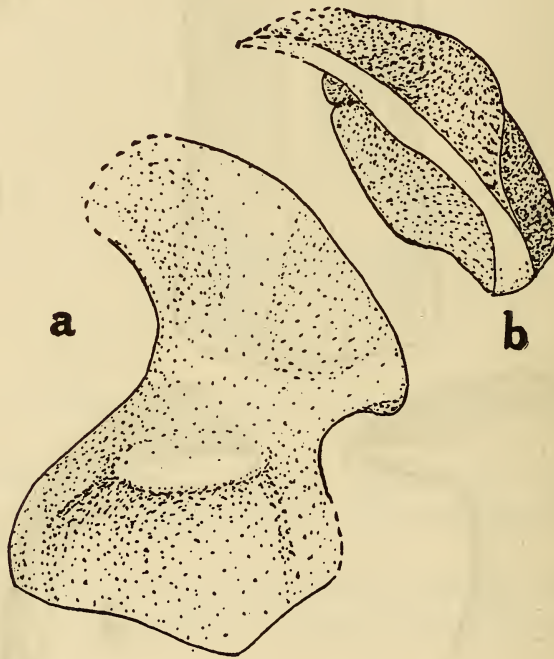


Interclavicae. ($\times \frac{1}{2}$.) a. Titanosuchian gen. indet. S.A.M. 11571. Dorsal view. b. Titanosuchian gen. indet. S.A.M. 11571. Lateral view. c. *Jonkeria* cf. *parva*. S.A.M. 11886. Ventral view. d. *Jonkeria* cf. *parva*. S.A.M. 11886. Lateral view.

S.A.M. 11986. An isolated ilium (Fig. 101). Letjiesbos, Beaufort West. Mid *Tapinocephalus* zone. Coll. Boonstra.

This ilium has on the outer face of the posterior iliac process neither the horizontally placed ilio-fibularis ridge, usually seen in the *Tapinocephalia*, nor the obliquely placed ridge, usual in the *Titanosuchia*. The area of origin of the ilio-fibularis is rather a thickening of the postero-ventral edge without any eversion or folding over. In outline this ilium agrees more with those of the *Titanosuchia*.

Fig. 101.



Ilium of a ? *Titanosuchian*. S.A.M. 11986. ($\times \frac{1}{6}$)
a. Lateral view. b. Dorsal view.

Anteosauria

Infra-ordinal Characters of the Girdles and Limbs.

The pectoral girdle is light; the scapular head of the triceps originates from a prominent tubercle; the outer face of the precoracoid is strongly convex and the glenoidal facet on the coracoid is bipartite.

The humerus is fairly light; without an ectepicondylar foramen; the radial condyle is well modelled, but situated well distally; both the processus lateralis and medialis lie far proximally; the delto-pectoral crest is very short and is directed much postaxially.

In the manus the carpal formula is 3, 1, 5, and the phalangeal formula 3, 3, 4, 4?, 2.

The iliac blade is low and the acetabulum faces much ventrally; the ilio-fibularis ridge lies horizontally; no supra-acetabular buttress is developed.

The femur is light, long and slender with the internal trochanter developed as a ridge; the width over the external trochanter is very small.

In the pes the tarsal formula is 2, 1, 5 and the phalangeal formula 2?, 3?, 3?, 4?, 2.

Anteosauridae

Family Characters of the Girdles and Limbs.

The Anteosaurid pectoral girdle is only imperfectly preserved in two specimens; but, even so, it is evident that the Anteosaurid girdle differs greatly from that of all the other Deinocephalia.

The girdle is of moderate size and is lightly built. No complete scapula is known but it would appear that it was of moderate width and height (455-475 mm. as reconstructed); instead of a tricipital mound or ridge, as in all the other Deinocephalia, there is developed (for the origin of the scapular head of the triceps) a prominent tubercle on the posterior edge of the scapula 25-35 mm. above the glenoidal edge; the internal opening of the foramen supracoracoideus opens into the fairly deep subscapular groove; the glenoidal facet of the scapula is large and faces ventro-posteriorly, but also much externally, and the outer and posterior margins are sharp, prominent and well moulded.

The coracoidal plate is fairly long antero-posteriorly. The precoracoid is relatively large; its dorso-posterior apex, just posterior to the outer opening of the foramen supracoracoideus, forms a fairly long margin to the glenoid; here the outer face of the precoracoid forms a decided depression or recess to house the processus lateralis of the humerus, when this bone is in its forward position; the foramen supracoracoideus penetrates the bone obliquely so that it internally forms a groove in the sutural face and thus opens into the subscapular groove; the outer precoracoidal face is strongly convex, so that its lower edge is directed much medially.

The coracoid is small and light, but greatly thickened where it houses the lower half of the glenoid; this facet is bipartite — the inner and posterior moiety receives the head of the humerus in its posteriorly disposed position, and the outer and anterior moiety receives the humerus when it is disposed

anteriorly; the inner part of the facet is directed dorso-posteriorly and slightly externally, whereas the outer part is directed much externally.

Nothing is known of the cleithrum, clavícula and interclavícula.

The humerus, known only in three specimens, is fairly lightly built and fairly small to medium (length 300?-375 mm.); the proximal expansion is fairly small (width 162-168 mm.); the distal expansion is somewhat greater (width 200-205 mm.); the shaft is fairly long and slender (diams. 76-84 $\times$ 48-65 mm.); the delto-pectoral crest is very short and terminates a considerable distance proximal to the ventral opening of the entepicondylar foramen, and is directed much postaxially; the caput is narrowly oval; the processus medialis lies in the same plane as the caput, whereas the processus lateralis lies a little further proximally; the radial condyle is situated distally, but extends a little along the ventral face and also curves on to the dorsal face; the "twist" on the shaft is large (40°); the L.M.L. is fairly definite and the A.D.V.L. is sharp and prominent; the entepicondyle is fairly greatly expanded, with the foramen entering dorso-postaxially and leaving as a ventral slit; the ectepicondyle is well expanded as a thin plate of bone housing on its ventral face a groove for the passage of the radial vessels.

The only radius known is a light, slender featureless bone and the only known ulna (length 260 mm.) is crushed flat.

The manus in the only specimen known has the carpal formula 3, 1, 5 and the phalangeal formula 3, 3, 4, 4², 2.

The pelvis is only known from one imperfect ilium. This, however, shows that the Anteosaurids had an ilium of a type radically different from any known in the South African Deinocephalia. It is without the strong supra-acetabular buttress so typical of the Deinocephalia; instead, the acetabulum is dorsally bounded by a continuous curved ridgelike margin without a supra-acetabular notch; the thickly rounded posterior edge of the fairly short posterior process, from which the ilio-fibularis originates, lies horizontally as in the Tapinocephalia; the iliac blade was presumably short and low.

In Fig. 104 an orthoprojection, taken by pantograph, vertically on to the iliac part of the acetabulum (as is the case in all the figures showing the lateral aspect of the pelvis, i.e. a projection on to the median plane) is shown. But I believe that in the naturally articulated skeleton the iliac portion of the acetabulum, in this case, would be directed much more ventrally so that the disposition of the femur in the Anteosaurids would be radically different from the condition in all other Deinocephalia.

The femur of the Anteosaurids looks very different from that of the other Deinocephalians; although not very long (210-420 mm.) it appears very long because of its general slenderness and long shaft; the width over

the external trochanter is small and varies from 47 to 120 mm.; the shaft is narrow and has diameters ranging from 28×18 to 75×45 mm.; the external trochanter is situated far proximally and nearly in the same plane as the caput; the caput is short pre-postaxially and flows directly into the external trochanter; with the preaxial border deeply concave and the postaxial border convex the femur is a curved bone with the caput well preaxially and somewhat dorsally directed; the internal trochanter forms a low ridgelike tubercle situated well away from the preaxial face, with a resulting reduced inter-trochanteric fossa; the femoral condyles face much distally with the external one further distally than the internal one; the popliteal fossa is elongated; the epicondyles, in one specimen, form a thin sheetlike expansion, both pre- and postaxially; the femoro-tibialis ridge is weak and the area for the insertion of the ilio-femoralis is narrow; there is a strong ridge for the insertion of the pubo-ischio-femoralis internus.

The tibia is unknown.

The fibula is a lightly built long and slender bone with its proximal end strongly expanded and with the facets for the femur nearly terminal. Whereas the proximal end is flattened, the distal facet is broadly oval in outline; the preaxial face is fairly straight, whereas in the other *Deinocephalia* this is deeply concave.

The pes has the tarsal formula 2, 1, 5 and the phalangeal formula uncertain but probably 2?, 3?, 3?, 4?, 2.

Anteosauridae

The Family Characters are as for the infra-order.

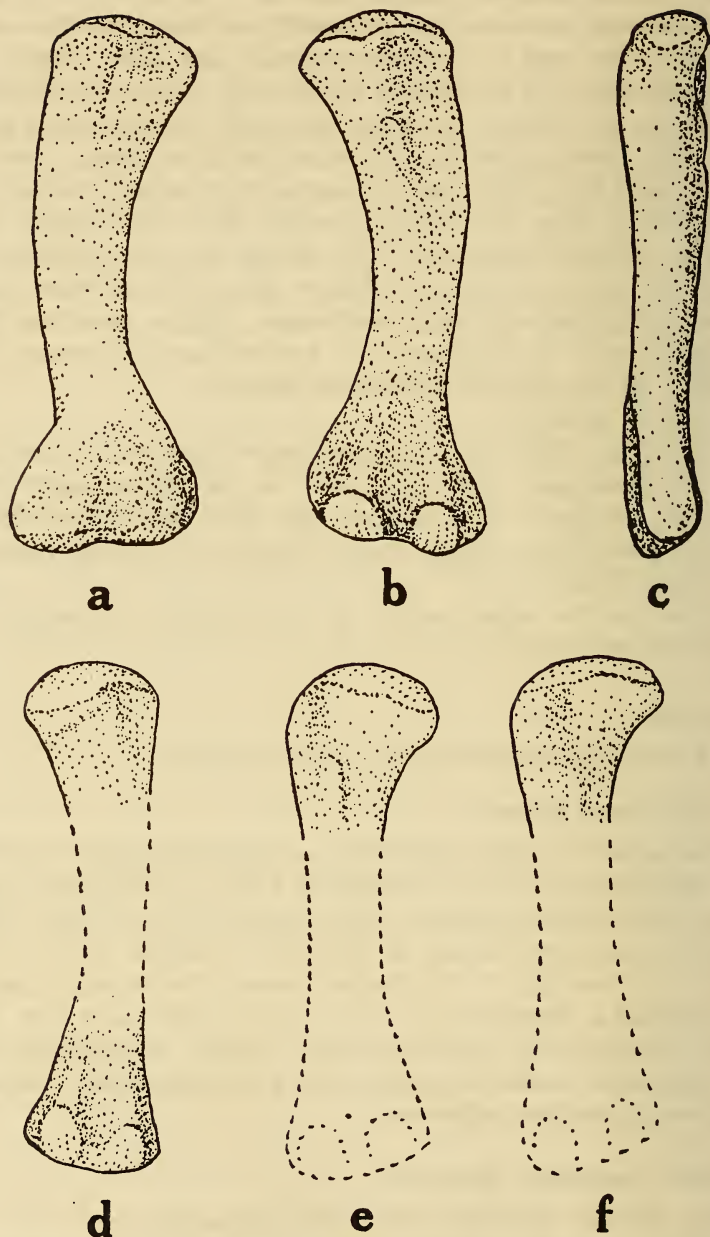
Genus *Anteosaurus* Watson

In this genus the girdles and limbs are very inadequately known. The generic characters that can be determined from an incomplete scapula, an incomplete and distorted humerus, three coracoids, an incomplete ilium, two good and two incomplete femora are as follows: Tricipital tubercle elongated, 35 mm. above the edge of the glenoid; humerus fairly small (length 300? mm.); the shaft is slender (diam. 60×48 mm.); the ilium is as described for the infra-order; the femur is slender (length 402?-420 mm.); width across the external trochanter 108-120 mm.; the epicondyles with moderate or pronounced sheetlike expansions.

Anteosaurus acutirostris (Boonstra).

Femur 420 mm. in length, with flaring epicondyles.

S.A.M. 11977A. Two good femora (Fig. 102 a-c), associated with a good skull (S.A.M. 9329). Kruisvlei, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

Fig. 102.

Femora. ($\times \frac{1}{2}$.) a. *Anteosaururus acutirostris*. S.A.M. 11977A. Dorsal view. b. *Anteosaururus acutirostris*. S.A.M. 11977A. Ventral view. c. *Anteosaururus acutirostris*. S.A.M. 11977A. Anterior view. d. *Anteosaururus* sp. S.A.M. 2753A. Ventral view. e. *Paranteosaururus primus*. S.A.M. 11485. Ventral view. f. *Anteosaururus* sp. S.A.M. 5614. Ventral view.

Anteosaurus lotzi (Broili and Schröder)

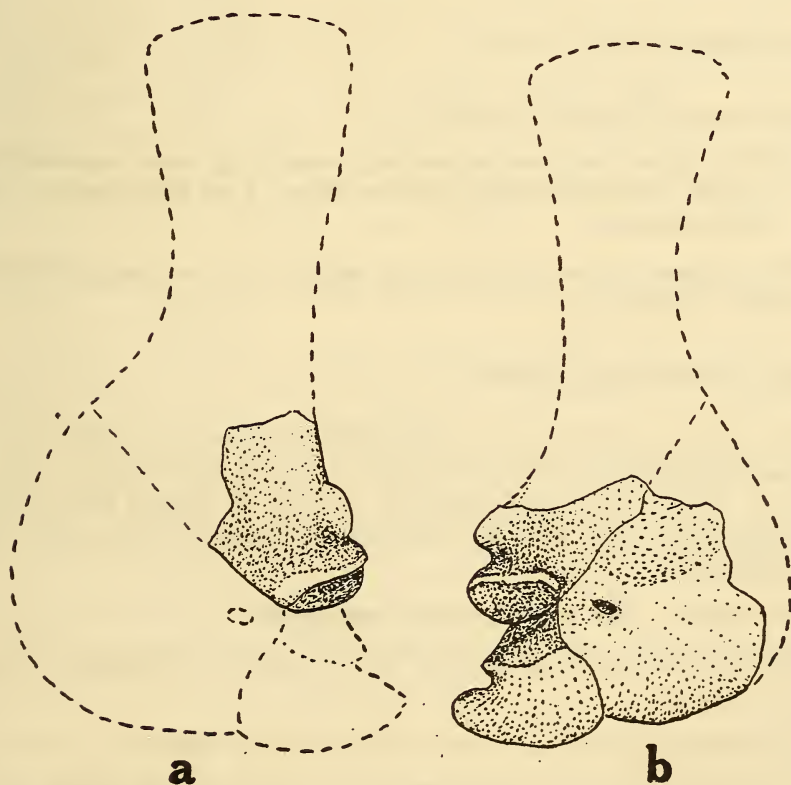
Alte Akademie. No. ?. Parts of an ilium, pubis and femur, associated with some skull pieces. Brakleegte, Beaufort West. High? *Tapinocephalus* zone. Coll. Schröder.

Little can be said about these fragments, but if the pubis is correctly determined and is as figured by Broili and Schröder, then this element is radically different from the pubes of other *Deinocephalia*.

Anteosaurus spp.

S.A.M. 2752. A partial distorted humerus and a coracoid, associated with a skull. Viviers Siding, Beaufort West. Mid *Tapinocephalus* zone. Coll. Haughton and Whaits.

Fig. 103.



Scapulo-coracoids. ($\times \frac{1}{2}$) a. *Anteosaurus* sp. S.A.M. 5614. Lateral view. b. *Eccasaurus priscus*. S.A.M. 11597. Lateral view.

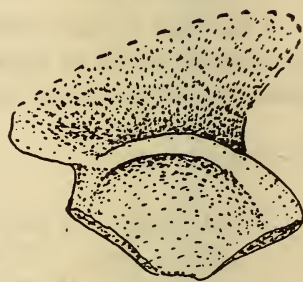
S.A.M. 2753A. Proximal and distal ends of a femur (Fig. 102d), associated with a skull fragment. Viviers Siding, Beaufort West. Mid *Tapinocephalus* zone. Coll. Haughton and Whaits.

Fig. 104.

S.A.M. 5614. Part of a scapula (Fig. 103a), an incomplete ilium (Fig. 104) and the proximal end of a femur (Fig. 102f), associated with two dentaries. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. Haughton.

S.A.M. 7396. An isolated coracoid. Abrahamskraal, Prince Albert. Low *Tapinocephalus* zone. Coll. van der Byl.

S.A.M. 11887. An isolated coracoid. Vindraersfontein, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.



Right ilium of *Anteosaururus* sp. S.A.M. 5614. ($\times \frac{1}{8}$.) Outer view.

Genus *Paranteosaururus* Boonstra

Paranteosaururus primus Boonstra

S.A.M. 11485. The proximal end of a femur (Fig. 102e), associated with a skull. Mynhardtskraal, Beaufort West. Low *Tapinocephalus* zone. Coll. Boonstra.

This fragment shows no features by which it can be distinguished from the femur of *Anteosaururus*.

Genus *Micranteosaururus* Boonstra

The femur is slender and curved (length 210 mm.); the width over the external trochanter is 47 mm.; the shaft is long and narrow (diams. 28 $\times$ 18 mm.); a "twist" on the shaft causes the caput to be directed much dorsally; the ectepicondyle (and probably also the entepicondyle) is without any sheet-like expansion.

The fibula is very long (138 mm.) and slender.

The pes has the tarsal formula 2, 1, 5 and the phalangeal formula 2?, 3?, 3?, 4?, 2.

The radius (105 mm.) is much shorter than the fibula.

The manus has the carpal formula 3, 1, 5 and the phalangeal formula 3, 3, 4, 4?, 2.

Micranteosaurus parvus Boonstra

As I (4) have only recently described this form, the above generic diagnosis of the limbs is extracted from that account, which consult for the figures.

Type: S.A.M. 4323. A coracoid, radius, manus, femur, fibula and pes, associated with a snout. Commonage of Merweville, Beaufort West. Low *Tapinocephalus* zone. Coll. Haughton.

Genus *Eccasaurus* Broom

Notwithstanding its very distinctive humerus (which constitutes the type specimen) Broom (9) included this genus in the Tapinocephalia and later even referred a typical Tapinocephalian tooth to this genus.

Although Broom in his original description only mentions the humerus there is in the South African Museum collection, associated with the type humerus, some skull pieces, two imperfect and weathered femora, a flattened radius?, some vertebrae, the distal end of a fibula, some other fragments and a long slender simple pointed tooth, which is probably an incisor.

The generic characterisation below is based on the type supplemented by features determined from a second specimen (S.A.M. 11597).

In the scapula the tricipital tubercle is oval in outline and is situated 25 mm. above the edge of the glenoid; the other features of the scapulo-coracoid are as described above for the family. The humerus is 348-375 mm. long and the width of the shaft is 76-84 mm.; other features as for the family.

The only known ulna is crushed dorso-ventrally; the length is 260 mm.

The pelvis is unknown.

The femur is 355 mm. in length and fairly slender; the width over the external trochanter (120 mm.) is larger than in *Anteosaurus*; the epicondyles are not laterally expanded as thin flanges.

There is thus no doubt that *Eccasaurus* with its long pointed incisor, its humerus with the delto-pectoral crest very short, its slender femur, where the external trochanter is situated so far proximally and so little laterally, and in the referred specimen (referred because of the great similarity in the humeri) the distinctive tricipital tubercle on the scapula, cannot possibly be a Tapinocephalian but is in fact an Anteosaurian.

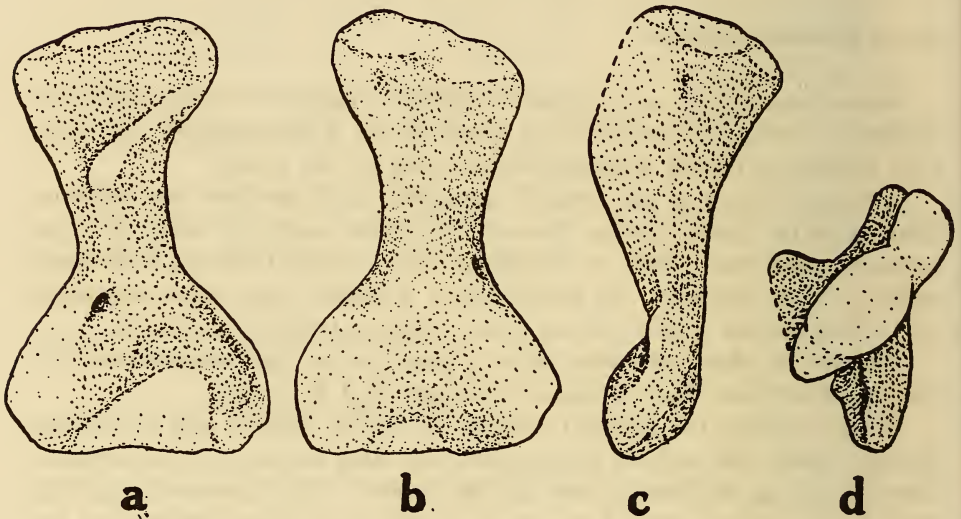
The tooth, which Broom has referred to *Eccasaurus*, does not belong to this genus but is typically Tapinocephalian.

Eccasaurus priscus Broom

The specific characters are as for the genus.

Type: S.A.M. 915. A good humerus (Fig. 105), two imperfect femora (Fig. 106), distal ends of the two fibulae (Fig. 107a) and a flattened ?radius, associated with parts of the skull. Sandvlakte, Prince Albert. Low? *Tapinocephalus* zone. Coll. Cairncross.

Fig. 105.



Humerus of *Eccasaurus priscus*. S.A.M. 915. ($\times \frac{1}{4}$.) a. Ventral view. b. Dorsal view. c. Anterior view. d. Proximal view.

Referred specimen:

S.A.M. 11597. Part of the right coracoscapula (Fig. 103b), an incomplete humerus and an ulna (Fig. 107b). Dikbome, Laingsburg. Low *Tapinocephalus* zone. Coll. Boonstra.

?*Anteosauridae Incertae Sedis*

S.A.M. 11996. An isolated interclavicula (Fig. 108). Koedoeskop, Beaufort West. Mid *Tapinocephalus* zone. Coll. Boonstra.

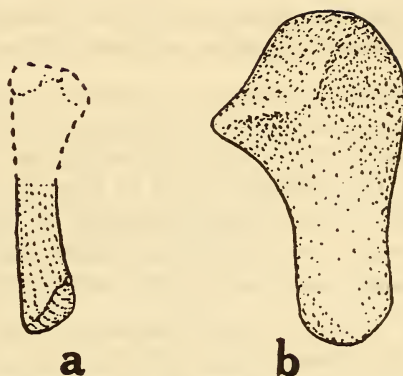
This interclavicle is small, with a short, fairly narrow stem, and the anterior widely spatulate end is not curved up sharply. I am tentatively referring this bone to the *Anteosauridae* as it cannot belong to any of the other *Deinocephalians*, where this element has quite different features.

Fig. 106.



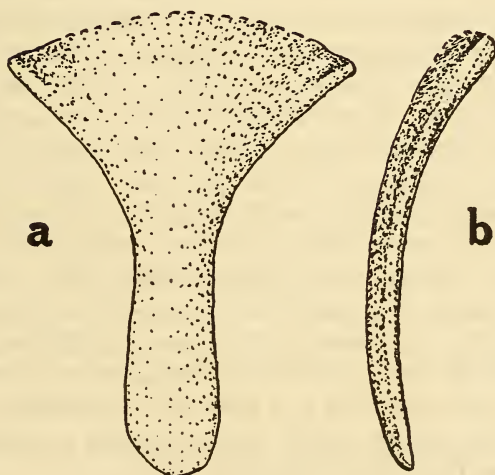
Femur of *Eccasaurus priscus*. S.A.M. 915.
($\times \frac{1}{6}$.) a. Ventral view. b. Anterior view.

Fig. 107.



Eccasaurus priscus. ($\times \frac{1}{6}$.) a. S.A.M. 915.
Fibula in ventral view. b. S.A.M. 11597.
Ulna in dorsal view.

Fig. 108.



Interclavicle of an ? Anteosaurid. S.A.M.
11996. ($\times \frac{1}{8}$.) a. Ventral view. b. Lateral
view.

CERTAIN PALAEOBIOLOGICAL CONCLUSIONS

From the above study it is abundantly clear that we still know very little about the girdles and limbs of the South African Deinocephalia.

Complete skeletons are unknown and moderately complete skeletons are extremely rare. In the herbivorous Tapinocephalia we have most specimens in which a fair amount of the skeleton has been found in association; in all about ten specimens (half of them of Moschopids) are known with a fair amount of the skeleton preserved in association. For the rest the specific and generic accounts are composite and based on a number of individuals, each with some part of the skeleton preserved, supplementing each other.

In the carnivorous Titanosuchia only two specimens have a fair amount of the skeleton of an individual animal preserved in association. In the Anteosauria only a few bones in all are known and in the Styracocephalia nothing whatever of the postcranial skeleton is known.

An inventory shows that parts of the girdles and limbs are known in 20 genera, and in 11 genera nothing at all is known of this part of the skeleton.

Now it is of interest to note that articulated partial skeletons have been more often found in the case of the Tapinocephalia than in the other infra-orders. This denotes a difference in the vicissitudes of entombment apparently largely due to differences in habitat. The two or three skeletons found in isolation were probably entombed in much the same manner as were the contemporary Pareiasaurs. In the two cases of mass-entombment of *Moschops* herds the conditions were different. Broom considered that the material of *Moschops* found by Whaits at Spitskop in the Moordenaarskaroos represents a herd of males, females and young. In the *Moschops*-material found by me at Kruisvlei in the Koup there are also males, females and juveniles, but here they were found together with remains of at least two individuals of the Anteosauria. There does not appear to be sufficient evidence for concluding that the two *Moschops*-finds represent herds overwhelmed by some catastrophe whilst peacefully feeding. It appears more probable that, living together in a certain suitable area, the remains were included in the sediment in a bed where deposition was taking place when death, not necessarily catastrophically or even simultaneously, overtook them. At Kruisvlei the bed in which the remains were found is not much more than about a foot thick and is a fairly fine argillaceous sandstone and the disposition of the various partial skeletons points to their having been transported by water for a short distance at least.

The other Tapinocephalian, and by far the majority of the Titanosuchian and Anteosaurian specimens, were found as isolated specimens consisting

of only a few bones not articulated but entombed quite near each other. The main reason for this scattering of the remains I believe to be due to the activities of carrion-eaters and the effects of water transport from higher to lower ground.

The above preliminary study of the locomotor apparatus in three of the infra-orders of the Deinocephalia has revealed three main types of locomotion. Without going deeply into this subject, at this stage, I can briefly indicate the broad differences that have become apparent.

In the Tapinocephalia the articulatory facets of the elbow-joint are weakly modelled and must have contained considerable cartilage. In addition the humeral condyles are situated much distally. This distal situation of the humeral condyles may indicate a more upright stance of the fore-limb when standing on firm ground. This is very probably the case in *Moschops* and its close relations, but in the Tapinocephalids and in many of the Struthiocephalids I am more inclined to think that the unfinished articulation is more indicative of a life spent much in water — but by no means as aquatic as the later Lystrosaurus. These reptiles living in the marshy parts of the Karroo basin, often wallowing in the water, but coming on firmer ground for part of their feeding would then, on death, be more likely to be entombed as fairly complete cadavers.

In the Titanosuchia the radial condyle is well modelled and the elbow-joint forms a much stronger and efficient hinge for terrestrial locomotion. But, the condyle being situated more on the ventral face of the humerus, this bone would in striding lie much more horizontally than in the Tapinocephalia. However, in the hind-limb, where the femoral condyles are placed much distally, the femur would be approaching a semi-upright position and the efficient joint with the tibia allows of the transmission of a powerful thrust by the hind-limb. Moreover, the muscle scars on all the elements of the stoutly built girdles and limb-bones are strong and indicate a muscular action much more powerful than in the Tapinocephalia and capable of the execution of sudden, rapid and forceful movements, which would be necessary for these carnivores. Thus the Titanosuchia, although having the chest slung fairly low between the fore-limbs, would be fairly active reptiles of prey, living chiefly on firm ground with little of the wallowing partaken of by the Tapinocephalia.

In the Anteosauria little is as yet known of the locomotor apparatus. The nature of the hip-joint and the structure of the femur seem to point to a crawling habit, showing, in some respects, much similarity to that of the modern crocodiles, but the dentition seems to indicate that they were possibly slinking carrion-eaters.

REFERENCES

1. BOONSTRA, L. D. A Note on the Synonymy of the two Deinocephalians, *Dinophoneus ingens* Broom and *Jonkeria pugnax* (Broom). S. Afr. Jour. Sci. 32, 329-331. 1935.
2. BOONSTRA, L. D. Some Features of the Cranial Morphology of the Tapinocephalid Deinocephalians. Bull. Am. Mus. Nat. Hist. 72, 75-98. 1936.
3. BOONSTRA, L. D. The Cranial Structure of the Titanosuchian: *Anteosaurus*. Ann. S. Afr. Mus. 42, 2, 108-148. 1954.
4. BOONSTRA, L. D. The Smallest Titanosuchid yet recovered from the Karroo. Ann. S. Afr. Mus. 42, 2, 149-156. 1954.
5. BOONSTRA, L. D. *Struthiocephalellus*: A New Deinocephalian. Ann. S. Afr. Mus. 42, 3, 180-184. 1955.
6. BROILI, F. and SCHRÖDER, J. Ein Dinocephalen-Rest aus den unteren Beaufort-Schichten. Sitzb. Bay. Akad. Wiss. Sonderdruck, 93-114. 1935.
7. BROOM, R. Notice of a new Fossil Reptile (*Scapanodon duplessisi*) from the Lower Karroo beds of Prince Albert, Cape Colony. Rec. Alb. Mus. 1, 3, 182-183. 1904.
8. BROOM, R. Notice of some new Fossil Reptiles from the Karroo Beds of South Africa. Rec. Alb. Mus. 1, 5, 331-337. 1905.
9. BROOM, R. Notice of some New South African Fossil Amphibians and Reptiles. Ann. S. Afr. Mus. 7, 3, 270-278. 1909.
10. BROOM, R. Further Observations on South African Fossil Reptiles. Am. Mus. Jour. 14, 135-143. 1914.
11. BROOM, R. On the Origin of Mammals. Phil. Trans. Roy. Soc. B. 206, 1-48. 1914.
12. BROOM, R. Permian, Triassic and Jurassic Reptiles of South Africa. Bull. Am. Mus. Nat. Hist. 25, 2, 105-164. 1915.
13. BROOM, R. On *Tapinocephalus* and Two Other Dinocephalians. Ann. S. Afr. Mus. 22, 3, 427-438. 1928.
14. BROOM, R. On the Carnivorous Mammal-like Reptiles of the Family Titanosuchidae. Ann. Transv. Mus. 13, 1, 9-36. 1929.
15. BROOM, R. The Mammal-like Reptiles of South Africa. pp. 18-46. Witherby, 1932.
16. BYRNE, F. A Preliminary Report on a New Mammal-like Reptile from the Permian of South Africa. Trans. Kans. Acad. Sci. 40, 221-231. 1940.
17. GREGORY, W. K. and CAMP, C. Studies in Comparative Myology and Osteology No. III. Bull. Am. Mus. Nat. Hist. 38, 15, 447-563. 1918.
18. GREGORY, W. K. The Skeleton of *Moschops capensis* Broom, a Dinocephalian Reptile from the Permian of South Africa. Bull. Am. Mus. Nat. Hist. 56, 3, 179-251. 1926.
19. HAUGHTON, S. H. On a Skull of *Tapinocephalus atherstonei*, Owen. Ann. S. Afr. Mus. 12, 1, 40-42. 1915.
20. HAUGHTON, S. H., in Report of the South African Museum for 1915, p. 4. 1916.
21. HUENE, F. von. Beitrag zur Kenntnis der Fauna der südafrikanischen Karroo-formation. Geol. Pal. Abh. 18, 3, 159-227. 1931.
22. LYDEKKER, R. Catalogue of the Fossil Reptilia and Amphibia in the British Museum (Natural History) IV, 81-98. 1890.
23. OWEN, R. Descriptive and Illustrated Catalogue of the Fossil Reptilia of South Africa in the Collection of the British Museum, 1-86. 1876.
24. OWEN, R. Description of Parts of the Skeleton of an Anomodont Reptile (*Platypodosaurus robustus*, Ow.) from the Trias of Graaff-Reinet, S. Africa. Quart. Jour. Geol. Soc. 36, 414-425. 1880.
25. ROMER, A. S. The Locomotor Apparatus of Certain Primitive and Mammal-like Reptiles. Bull. Am. Mus. Nat. Hist. 46, 10, 517-606. 1922.
26. ROSSOUW, P. J. en DE VILLIERS, J. Die Geologie van die Gebied Merweville, Kaapprovinsie. Toel. Blad. 198. Geol. Opname, Unie S. Afr., 1-71. 1952.
27. SEELEY, H. G. Researches on the Structure, Organisation and Classification of the Fossil Reptilia. II. On *Pareiasaurus bombidens* (Owen), and the Significance of its Affinities to Amphibians, Reptiles and Mammals. Phil. Trans. Roy. Soc. 179, B. 59-109. 1888.
28. SEELEY, H. G. Researches on the Structure, Organisation and Classification of the Fossil Reptilia. VI. On the Anomodont Reptilia and their Allies. Phil. Trans. Roy. Soc. 180, B. 215-296. 1889.
29. WATSON, D. M. S. The Deinocephalia, an Order of Mammal-like Reptiles. Proc. Zool. Soc., 749-786. 1914.